Railway Mechanical Engineer

Reading Locomotive Shop

Reading Lines

DURING the past six years the Reading Company has concentrated the major part of its locomotive repair work at its main shop at Reading, Pa. This shop was built in 1905 and consists principally of a main machine and erecting shop 200 ft. by 750 ft. having 68 erecting pits of the transverse arrangement, 34 on each side of the building, with a large machine bay the full length of the building between the two erecting bays. At the north end of this building and continuous with it is a 192-ft. by 404-ft. extension containing the locomotive wheel and driving box departments. In this extension are also longitudinal repair tracks where Mallet type locomotives and rail motor cars are repaired. Locomotives enter and leave the main shop by a track served by a turntable; the
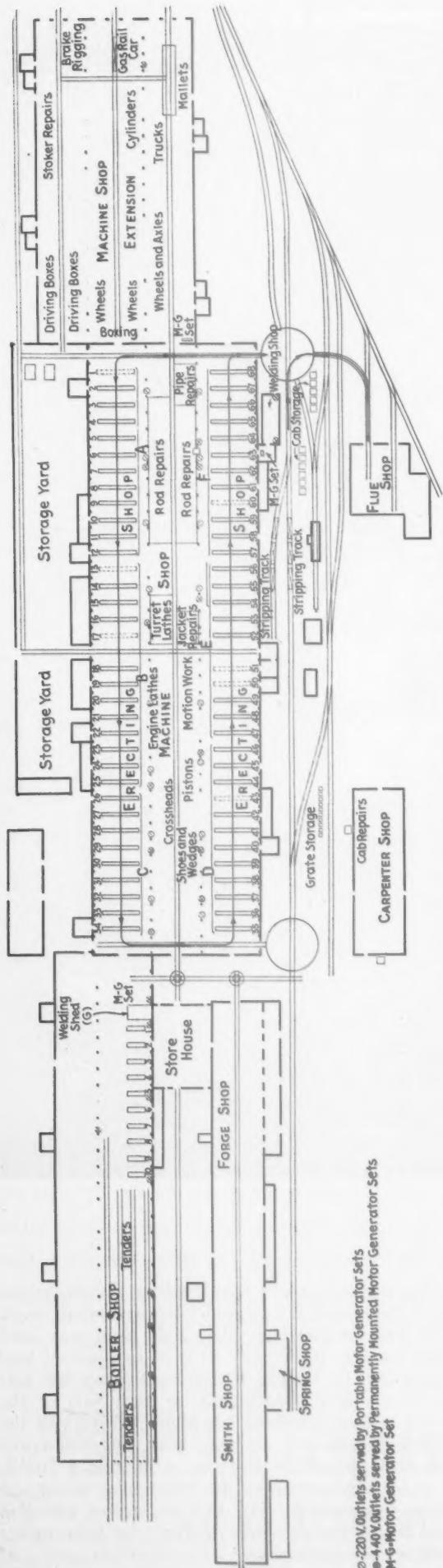
Layout of the Reading locomotive repair shop showing the location of the various departments and the route taken by locomotives undergoing repair

⊙ -220 V. Outlets served by Portable Motor Generator Sets
⊕ -440 V. Outlets served by Permanently Mounted Motor Generator Sets
M-G-Motor Generator Set

Introduction of progressive repair system and the installation of \$227,000 worth of new shop equipment contribute to a reduction of 27 per cent in locomotive shop time and 24 per cent in repair cost

machine shop extension is served by tracks entering at the north end of the building. Adjacent to the machine and erecting shop are the blacksmith shop, boiler shop, foundry and carpenter shop.

The Reading Company owns 775 steam locomotives of which 708 are of the following types:

Service	Type	No. Owned
Switching	0-6-0	72
	0-8-0	42
Passenger	4-4-0	24
	4-6-0	68
	4-4-2	22
	4-6-2	40
Freight	2-8-0	353
	2-8-2	57
	2-10-2	10
	2-8-8-2	20

Of these 708 locomotives, comprising over 91 per cent of the ownership, 306 are less than 20 years old. It will be noted that almost half of the Reading motive power, 45.5 per cent, consists of Consolidation type locomotives, 150 of which are less than 20 years old.

During the depression the Reading Company encountered problems common to most American railroads. Between 1930 and 1934 operating revenue dropped 45 per cent, with a reduction of over 30 per cent in revenue ton-miles. Transportation service locomotive miles dropped 38 per cent and, as a result, expenditures for steam locomotive repairs were reduced 47 per cent.

Faced with the problem of maintaining efficient transportation service under such conditions the management

Dismantling a pair of wheels destined for the scrap pile—tires are cut through with a torch

Locomotives are stripped in Section A outside the shop

set out to adapt its operations to changing conditions. Those in charge of the locomotive repair work made detailed studies of the repair problem, particularly as related to classified locomotive repairs, with the result that in 1932 the Reading took a radical step and changed the shop operation over from the former conventional system of repairing locomotives at fixed shop locations and introduced a progressive or "spot" system of repairs, in which certain sections of the shop were equipped for specialized repair work and the locomotives moved from section to section during the progress of their passage through the shop. The results so far obtained since the introduction of this progressive system are of particular interest to railroad men because of the fact that the progressive system of locomotive repairs has not been generally believed to be well adapted to the transverse type of shop. It must be borne in mind that, under the

necessarily curtailed operations of the past four years, it is not possible to determine conclusively the potentialities of any type of railroad shop repair system, but the results so far obtained at Reading, with the shop operating at not much more than 35 to 40 per cent of its capacity, indicate that the economies so far effected have justified the step that has been taken.

Once the progressive system had been established on a working basis it became evident to those responsible for shop operations that it would not be possible to effect the desired savings unless many of the older units of machine tool equipment were replaced. Consequently another series of studies were made which, when completed, pointed definitely to the fact that a modernization program as regards shop facilities would make it possible to effect substantial economies in locomotive repair work. These studies resulted in the replacement of 49 old
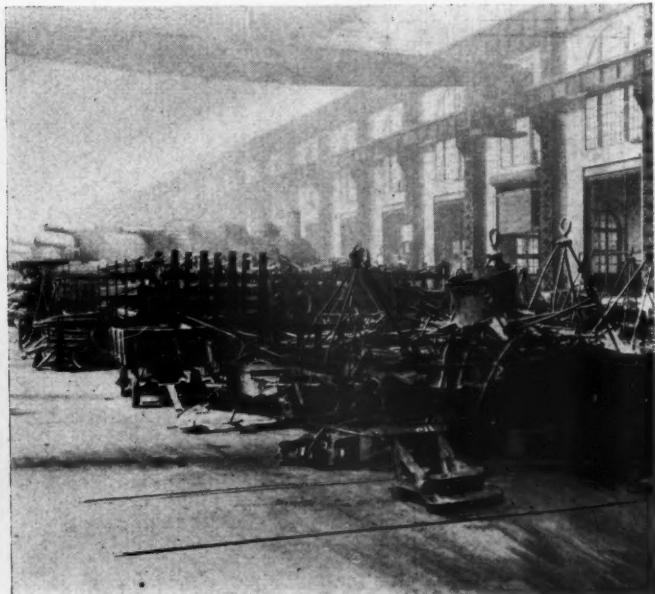
Two of the locations inside the shop where repaired and finished locomotive parts are stored awaiting assembly

machine tools averaging approximately 35 years in age by 32 modern machines at an expenditure of approximately a quarter of a million dollars.

The Progressive System

The progressive system as applied to the Reading Shop is operative only in the main erecting shop, and does not apply to the work on Mallet type engines in the machine shop extension at the north end of the shop. The erecting department was originally divided into four sections, the same work being performed in each section, making it necessary for workmen to go to each of the four sections of the shop in order to perform similar work. Under the progressive system this has been changed, so that each class of work is performed in one section only. The definite operations are grouped in a sequence from beginning to end, each group being performed at designated locations which are known as "sections," there being six of these in all, three in the East bay of the shop and three in the West bay.

The sections are designated by letters, and each section is distinguished by a different color which appears on the section marking sign located on the shop wall. At each pit location there is also a marker sign, which shows the number of the locomotive which is on that pit at any given time. These marker signs simplify the problem of locating any particular locomotive. In general the principal difference between the progressive system and the former conventional system, is that the locomotives move to the workmen rather than the workmen to the locomotives. Individual sections of this shop have been fitted to do specialized work with convenient racks for the storage of locomotive parts. Material ordered for application to locomotives is delivered to these various sections in accordance with the schedule calling for its application. The general operations involved in locomotive repair work which are performed at each section are as follows:

Color designation	Letter	Operation
Red	A	Stripping, unwheeling, cleaning.
White	B	Light boiler work, heavy boiler work, flues applied, boring cylinders, fitting braces.
Blue	C	Light boiler work, heavy boiler work, flues applied, boring cylinders, fitting braces.
Green	D	Frame work and cylinders, dry pipe, steam pipe, throttle and throttle rigging, waist sheets, pressure fittings, testing boiler.
Brown	E	Jacket, cab, footboards, etc., grates, ashpans, smokebox, spring rigging, valve rigging, stokers, injectors, air pump, guides, pilots, couplers, etc.
Yellow	F	Wheeling, pipe work, rods applied, shoes and wedges, pedestal braces, brake rigging, valve setting, finishing, inspecting.

Inasmuch as the tracks in this shop are transverse in arrangement it is necessary to lift a locomotive by crane from one section to another. After the work in the three sections of the West bay has been completed the locomotives are moved across the South end of the shop to the East bay by means of a tractor. Each of the bays in the machine and erecting shop is adequately served by traveling cranes. Locomotives coming to the shop for repairs are moved into the shop yard and placed in the stripping location outside of the East side of the shop. This stripping location forms part of Section A. At this point, cabs, jackets, brake rigging, smokebox fronts, reservoirs, steam pipes, stokers and grates are removed. When flues require renewal they are removed at this section and an internal inspection is made of the boiler and firebox. The wheels and rods are left

After work is completed in Section C the engines are moved across the shop by tractor

The wheeling of a locomotive is done on the night shift—the wheels, boxes and rods are made ready and the wheeling is done on a specially-equipped pit

on the locomotives to be removed later, after they have been taken into the shop. The stripping track is served by a steam locomotive crane.

After the preliminary stripping operation has been completed, the locomotives are moved to a turntable at the northeast corner of the shop and delivered over a track extending across the north end of the erecting shop to Section A where the final unwheeling and cleaning is performed. After the parts which have been removed from the locomotives have been cleaned, (including piping, pedestal braces, clamps, steam pipes, throttle rigging, etc.), they are stored in the yard outside of the shop. Under the former system of shop operation, this material was stored in pits adjacent to the repair tracks. This caused considerable congestion in the shop and constituted somewhat of a hazard to the workmen. Under the present method this material is stored at fixed locations where it is conveniently accessible, and is delivered back to the shop at the finishing location when required.

After the work in Section A has been completed the locomotive is then lifted by the overhead crane to Section B or C. Whether a locomotive, in its progress through the shop, enters section B or C depends upon the extent of the boiler work to be performed; heavy boiler repair jobs, such as heavy firebox work, are performed in Section C exclusively. A locomotive may or may not spend time in all six sections of the shop depending upon the nature and extent of the work to be done. On particularly light repair jobs it is quite possible that certain sections of the shop may be skipped by a locomotive in its progress through the shop.
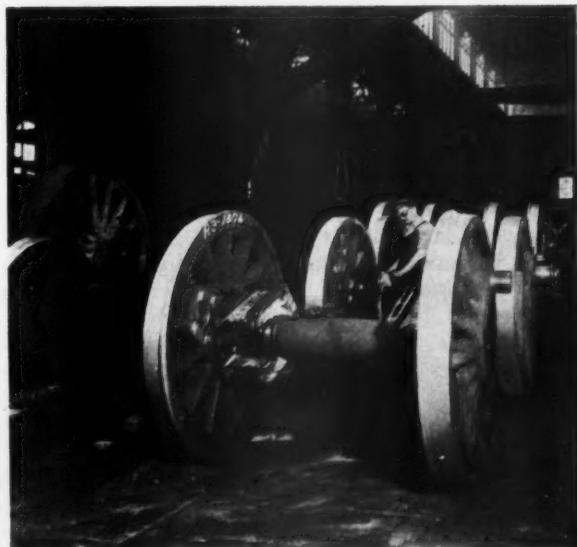
A view in the wheel department showing a workman fitting up a set of driving boxes

After the work in Section B or C has been completed the locomotive is removed by tractor across the shop to section D, where the heavy machine work such as frame work and cylinders is done. In this section such work as dry pipe, steam pipe, throttle and throttle-rigging repairs is taken care of, and the necessary tests on the boilers are made. After work in Section D is completed, the locomotive is lifted by crane to Section E which is the first of the two final assembly positions. Here the jacket, cab and running boards are applied. The smokebox work is done, grates and ashpans are applied, spring

Mallet type locomotives are repaired at a special location equipped with a Whiting hoist

rigging, valve gears, injectors, air pumps, guides, pilots, couplers, etc., are all put on.

From Section E the locomotive is lifted to the finishing section, which is designated as F. One of the pits in this section is especially equipped for wheeling engines. Here the wheels and rods are assembled, driving boxes and shoes and wedges are put up and when these parts are ready the locomotive is lifted over and wheeled. This work is done on a second trick so as not to interfere with the routine work of the first-trick workmen. After the engine is wheeled, the brake rigging is applied, the valves are set and the engine is ready for its final finishing and inspection. A certain part of the painting is done in Section F and then the locomotive is moved to the enginehouse, which lies immediately north of the shop, where the final painting is done and the engine fired up. The operations involved in Section F include the final work in the enginehouse. The finish painting of a locomotive is not done until after it has made its break-in run and all repairs and adjustments necessary as a result of the break-in have been made. This assures that when the locomotive is finally turned over to the transportation department it presents a neat appearance.

All of the operations in the locomotive department are controlled by a master schedule system. When a locomotive is taken into the shop for repairs, it is first thoroughly inspected and the class of repairs determined.

Depending upon the class and nature of the repairs, a given number of working hours is allowed to complete the work on the locomotive. Each department in the shop is allowed a specific time for the completion of its part of the work and the shop supervisor follows the progress of all of the departmental work, in order that delays may be avoided. The progress reports of parts passing through repairing departments are entered on a departmental schedule form and a master schedule sheet is posted, so that it is possible to determine whether or not the work on any particular locomotive is proceeding according to the predetermined schedule.

An analysis of the number of shop days required to repair, for example, Reading type 2-8-0 or 4-6-2 locomotives shows that since the installation of the progressive system the following reductions in the scheduled time in the shop have been effected:

On Class 2 repairs	29.0 per cent
On Class 3 repairs	27.5 per cent
On Class 4 repairs	26.0 per cent
On Class 5 repairs	24.0 per cent
On recondition repairs	30.0 per cent
Average reduction	27.0 per cent

Material Distribution

At the time of the introduction of the progressive repair system a material delivery system was established, which obviates the necessity of workmen leaving their
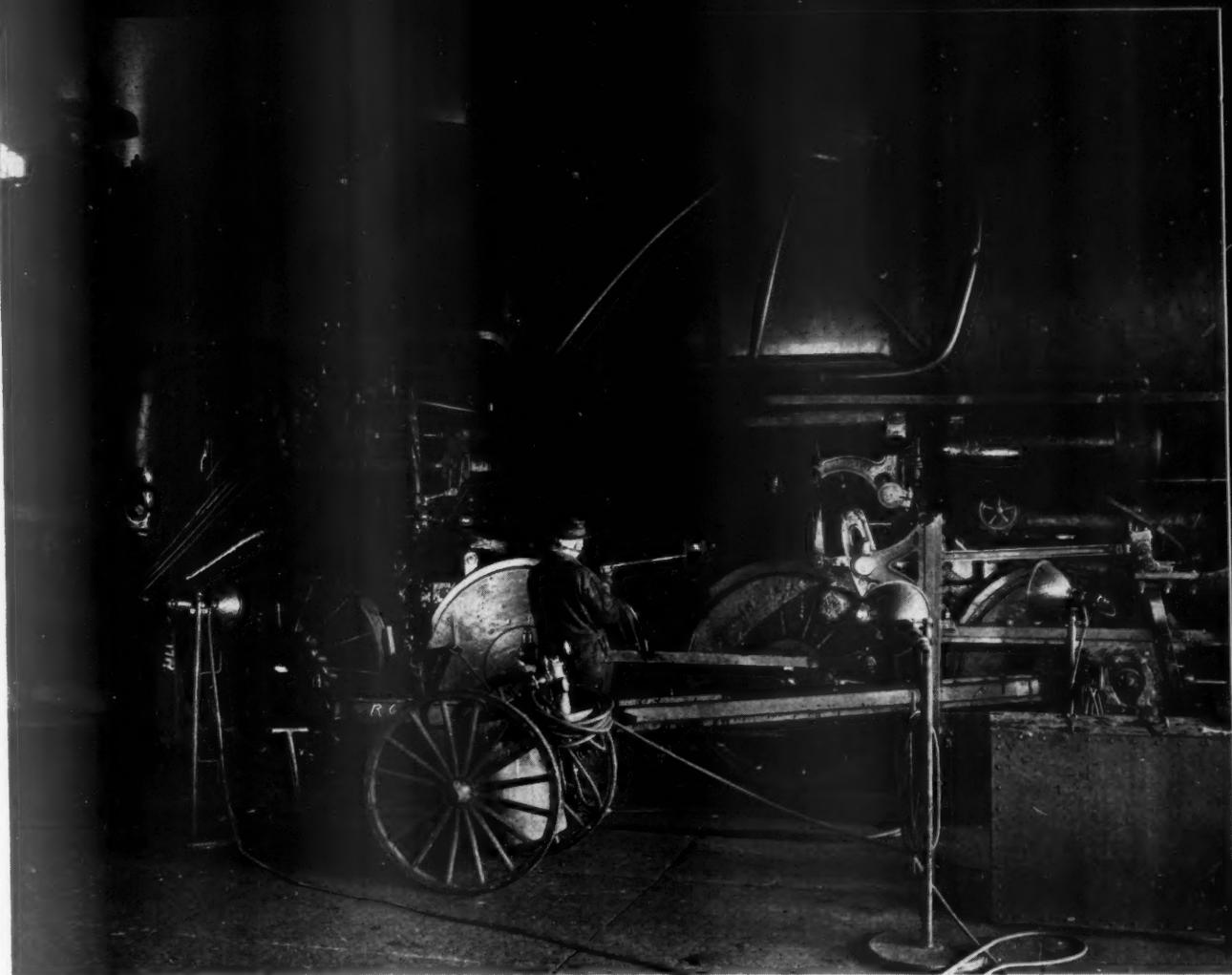
The finished painting on a locomotive is done by the spray process in Section F

posts for any material that may be required in the process of repair work. Locomotive parts which have been removed are distributed to the proper departments for repair by means of this delivery system and finished parts and material from the store house are delivered in a like manner. The delivery system utilizes tractors and trailers, and operates over eight designated routes—seven of which serve the locomotive departments. One route serves the general store house, oil house, electric and superheater repair shops; another route serves the enginehouse and wheel shop. Three routes serve the machine and erecting shops and the machine shop extension; one route serves the foundry, boiler shop and blacksmith shop, and, a seventh route operates between the main shop and the enginehouse. The eighth route is confined entirely to the car shop.

Machine Shop Modernization

It became evident after the introduction of the progressive repair system that substantial economies could be effected by modern machine tools. There are, in the machine shop at Reading, approximately 300 major

A set of wheels, rods and boxes ready for the wheeling gang

Typical examples of the new facilities at Reading

1—One of the Warner & Swasey turret lathes
2—Metal-spraying an air pump piston
3—One of the new American radials
4—The impact wrench on staybolt caps
5—Finishing a locomotive piston head
6—Westinghouse welder for wheel centers
7—Finishing the cylinders of an air pump on the Micro grinder

Table I—Machine Tools Retired at Reading Shops

Machine	Manufacturer	Date purchased	Age, years
28-in. engine lathe	(Unknown)	1870	66
50-in. horizontal boring mill	Wm. Sellers Co.	1882	54
52-in. vertical drill	Wm. Bement & Son.	1883	53
20-in. engine lathe	E. A. Betts Machine Co.	1890	46
36-in. planer	Bement-Miles & Co.	1890	46
11-in. crank shaper	Bement & Dougherty	1890	46
30-in. vertical drill	Wm. Bement & Son.	1895	41
48-in. radial drill	Wm. Bement & Son.	1901	35
Four-spindle table drill	Foote-Burt Co.	1901	35
16-in. engine lathe	Lodge & Shipley	1901	35
2-in. x 24-in. turret lathe	Jones & Lamson.	1901	35
36-in. x 36-in. planer	Cincinnati Planer Co.	1901	35
14-in. x 52-in. universal milling machine	Pedrick & Ayer	1901	35
36-in. vertical boring mill	Bullard Company	1901	35
31-in. metal saw	Higley Machine Co.	1901	35
16-in. engine lathe	Lodge & Shipley	1902	34
28-in. engine lathe	Schumaker & Boye.	1902	34
48-in. radial drill	Wm. Bement & Son.	1903	33
48-in. semi-radial drill	Bickford	1903	33
16-in. engine lathe	Harrington Sons & Co.	1903	33
24-in. engine lathe	Schumaker & Boye.	1903	33
2-in. x 24-in. turret lathe	Jones & Lamson.	1903	33
36-in. vertical boring mill	Bullard Co.	1903	33
36-in. vertical boring mill	Bullard Co.	1903	33
31-in. metal saw	Higley Machine Co.	1903	33
30-in. gap grinder	Norton Company	1905	31
No. 4 universal grinder	Brown & Sharpe	1905	31
24-in. drill	Baker Brothers	1905	31
36-in. vertical drill	Baker Brothers	1905	31
36-in. radial drill	Dreses Machine Tool Co.	1905	31
48-in. semi-radial drill	Bickford	1905	31
20-in. engine lathe	Putnam & Son	1905	31
16-in. engine lathe	Hendey Machine Co.	1905	31
4-in. turret lathe	Bardons & Oliver	1905	31
2-in. x 24-in. turret lathe	Jones & Lamson	1905	31
2¼-in. x 26-in. turret lathe	Bullard Co.	1905	31
3½-in. x 26-in. turret lathe	Bullard Co.	1905	31
4¾-in. x 24-in. turret lathe	Gisholt	1905	31
18-in. shaper	Cincinnati Planer Co.	1905	31
No. 5 horizontal milling machine	Cincinnati Milling Machine Co.	1905	31
67-in. vertical milling machine	Bement-Miles & Co.	1905	31
30-in. vertical boring mill	Bullard Co.	1905	31
30-in. vertical boring mill	Bullard Co.	1905	31
58-in. vertical boring mill	Colburn	1905	31
58-in. vertical boring mill	Colburn	1905	31
34-in. vertical boring mill	Colburn	1905	31
36-in. vertical boring mill	Bullard Co.	1905	31
42-in. vertical boring mill	Bullard Co.	1905	31
12-in. x 60-in. milling machine	Newton	1905	31

Average age of machines retired—34.8 years

machine-tool units. About 85 per cent of these were purchased prior to or at the time the shop was built in 1905, the remaining 15 per cent having been purchased at various times since then. There has not, however, until now, been any major tool replacement program, with the result that many of the machines had outlived their economic usefulness.

As a result of the studies made 49 obsolete machines, having an average age of approximately 35 years, were retired and replaced by modern tools. A list of the machines retired appears in Table I, and a list of the new machines installed appears in Table II.

These new tools were placed at strategic locations throughout the shop. The rod department was furnished with two new 5-ft. radial drills, an Ingersoll vertical milling machine and the two 36-in. vertical boring mills, which are used on rod bushings. The Newton crank planer was installed in the shoe-and-wedge group, while the two 42-in. Bullard vertical turret lathes were installed in the piston and cylinder group working on cylinder packing rings, piston heads and piston valve bushings. The 54-in. Bullard vertical turret lathe is equipped with a high bed for handling cylinder bushings. The remaining two 5-ft. radial drills were installed in the motion-work group of the main shop and the driving-box group in the machine-shop extension. The motion-work group also received the Cincinnati No. 5 milling machine. The three American engine lathes are installed in the piston and crosshead department.

Among the changes made in connection with the machine-tool equipment of this shop was the relocation of many machines with the idea of grouping machines so that the various groups would be self-supporting as far as machine tool facilities are concerned. In carry-

Table II—New and Rebuilt Machine Tools Recently Installed at Reading Shops

Description of equipment	Name of manufacturer	Date placed in service	No. of motors	Hp.	Current characteristics	Manufacturer
Flash welder	Swift Electric Welder Co.	2/27/35	None			
Model FG internal grinder	Micro Machine Co.	8/14/35	1	5	3 ph. a.c. 220/440	Westinghouse
			1	2	3 ph. a.c. 220/440	Fairbanks-Morse
20-in. engine lathe*	American Tool Works Co.	8/19/35	1	5	2 ph. a.c. 220/440	General Electric
Flue cut-off machine	Andrew C. Campbell Co.	8/21/35	1	7½	2 ph. a.c. 220/440	General Electric
42-in. vertical turret lathe	Bullard Co.	8/22/35	1	25	2 ph. a.c. 220/440	Allis-Chalmers
36-in. vertical turret lathe	Bullard Co.	8/22/35	1	20	2 ph. a.c. 220/440	Allis-Chalmers
54-in. vertical milling machine*	Ingersoll Milling Machine Co.	8/22/35	1	25	2 ph. a.c. 220/440	General Electric
			1	¼	2 ph. a.c. 220/440	General Electric
36-in. shaper	Ohio Machine Tool Co.	8/22/35	1	20	2 ph. a.c. 220/440	Fairbanks-Morse
39-in. crank planer	Consolidated Machine Tool Corp.	8/23/35	1	10	2 ph. a.c. 220/440	Westinghouse
			1	¾	2 ph. a.c. 220/440	Westinghouse
No. 5 milling machine	Cincinnati Milling Machine Co.	8/26/35	1	20	2 ph. a.c. 220/440	Fairbanks-Morse
32-in. × 18-in. gap grinder*	Norton Co.	9/ 4/35	1	10	2 ph. a.c. 220/440	General Electric
7½-in. turret lathe*	International Machine Tool Co.	9/13/35	1	20	2 ph. a.c. 220/440	Westinghouse
54-in. vertical turret lathe	Bullard Co.	9/16/35	1	25	2 ph. a.c. 220/440	Allis-Chalmers
Cold saw	Espen-Lucas Machine Works	9/24/35	1	10	2 ph. a.c. 220/440	Westinghouse
			1	1	2 ph. a.c. 220/440	Fairbanks-Morse
36-in. vertical boring mill	Niles Tool Works	9/25/35	1	15	2 ph. a.c. 220/440	Fairbanks-Morse
5-ft. radial drill	Dreses Machine Tool Co.	10/ 7/35	1	15	2 ph. a.c. 220/440	Allis-Chalmers
			1	½	2 ph. a.c. 220/440	Allis-Chalmers
Two No. 5 universal turret lathes	Warner & Swasey	10/14/35	1	7½	2 ph. a.c. 220/440	Fairbanks-Morse
2A turret lathe	Warner & Swasey	10/16/35	1	15	2 ph. a.c. 220/440	Allis-Chalmers
14-in. × 36-in. grinder	Norton Co.	10/24/35	1	1½	2 ph. a.c. 220/440	Allis-Chalmers
			1	1½	2 ph. a.c. 220/440	Fairbanks-Morse
			1	¼	2 ph. a.c. 220/440	Westinghouse
5-ft. radial drill	Dreses Machine Tool Co.	10/21/35	1	15	2 ph. a.c. 220/440	Fairbanks-Morse
			1	½	2 ph. a.c. 220/440	Fairbanks-Morse
Stock adjusting machine	Watson-Stillman Co.	10/25/35	1	3	2 ph. a.c. 220/440	Westinghouse
42-in. vertical turret lathe*	Bullard Co.	11/ 7/35	1	25	2 ph. a.c. 220/440	Westinghouse
5-ft. radial drill	American Tool Works Co.	11/15/35	1	20	2 ph. a.c. 220/440	Allis-Chalmers
			1	½	2 ph. a.c. 220/440	Allis-Chalmers
2¼-in. Gridley automatic	National Acme Co.	11/18/35	1	20	2 ph. a.c. 220/440	General Electric
Two 18-in. engine lathes	American Tool Works Co.	11/21/35	1	10	2 ph. a.c. 220/440	Allis-Chalmers
5-ft. radial drill	American Tool Works Co.	12/ 3/35	1	20	2 ph. a.c. 220/440	Allis-Chalmers
			1	½	2 ph. a.c. 220/440	Allis-Chalmers
Driving box oil grooving machine	Lehman Machine Co.	12/ 4/35	1	5	2 ph. a.c. 220/440	Westinghouse
14-in. engine lathe	Monarch Machine Co.	1/ 9/36	1	10	2 ph. a.c. 220/440	Fairbanks-Morse
No. 2 die sinker	Pratt & Whitney	1/23/36	1	1	2 ph. a.c. 220/440	General Electric
			1	¼	2 ph. a.c. 220/440	General Electric
Automatic wheel center welder	Westinghouse Elec. & Mfg. Co.	1/25/36	1	7½	250 volts d.c.	General Electric

Special Shop Equipment Installed at Reading

Potts impact wrenches	Ingersoll-Rand Co.	12/26/34	..	..		
Hardness tester	Wilson Mechanical Instrument Co.	5/25/35	..	..		
Checking pyrometer	Thwing Instrument Co.	6/19/35	..	..		
Metal spray equipment	Metallizing Co. of America	8/ 8/35	..	..		
Foundry blast equipment	Pangborn Co.	8/23/35	..	..		
Electric furnace for heat treating	C. I. Hayes, Inc.	9/ 3/35	..	..		

* Rebuilt machine tools.

Part of the turret lathe group with new foundations ready for additional machines

ing this relocation out, the turret lathes are being placed in a turret-lathe group in the main shop. The 7½-in. Libby turret lathe and the No. 2A Warner & Swasey are located in this group, while the two No. 5 Warner & Swasey turret lathes are located temporarily in the brass-work group in the balcony over the driving-box section. The Gridley automatic is installed in the main turret-lathe group working on brake, spring-rigging and motion pins.

Another major change which has been made involving

machine work has been the establishment of an air-brake shop which handles all of the air-brake work—both car and locomotive—for the entire Reading System. This air-brake department is located in the new car shop building at Reading which was built in 1927. The Model FG Micro grinder mentioned in the list of new machine tools purchased was installed in this department as was also the metal-spray equipment. The Micro grinder is operated almost exclusively on air-pump and power-reverse-gear cylinders and the metal-spray equipment is
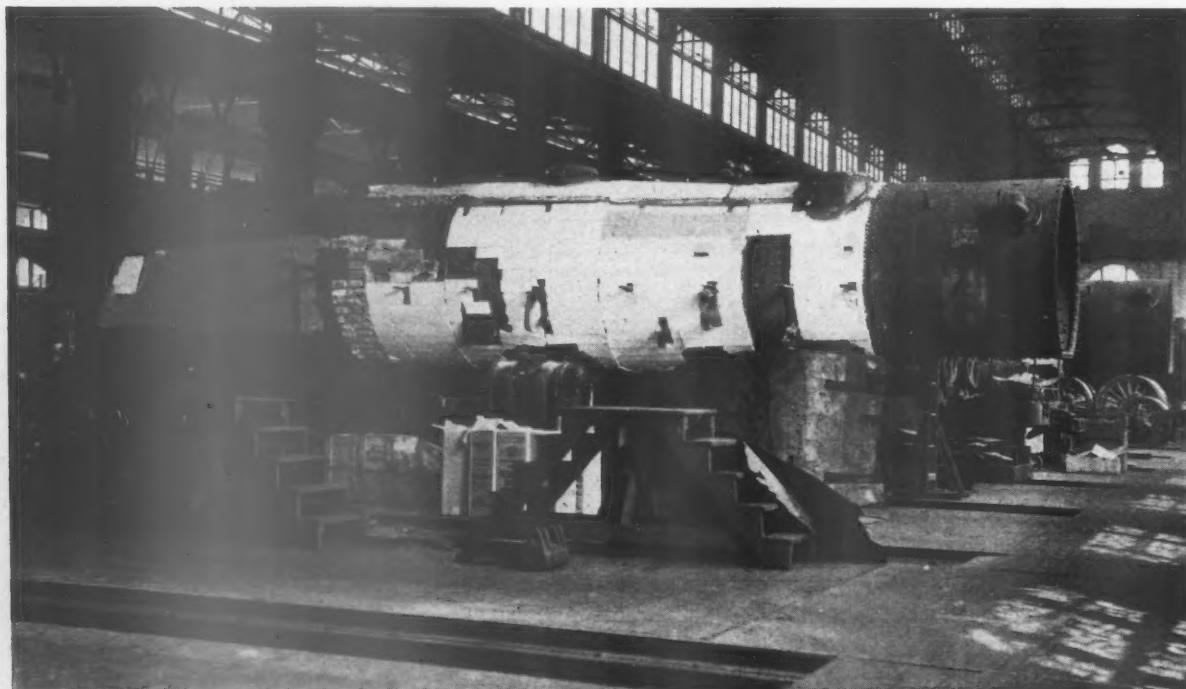
A view in the assembly section of the erecting shop

used a large part of the time on the building-up of air-pump and power-reverse-gear piston rods.

The Influence of New Tools

When the studies were made in 1933-1934 upon the basis of which these new tools were purchased the estimates of potential savings were predicated upon normal operations. It is worth while to point out that since that time operations have not been normal. During the year 1935 the total operating revenues of the Reading were about the same as 1933 and about four per cent greater than in 1934. Expenditures for steam locomotive repairs in 1935 exceeded 1933 by 14 per cent. The Reading Shop, on the basis of eight-hour days, worked 68 per cent of the potential number of working days—exclusive of Sundays and holidays—in 1935 but, on the basis of machine hours, the machine-tool facilities were utilized to only 35 per cent of capacity. Herein lies an important fact in relation to railroad machine tools, namely, that due to the nature of the work it is necessary to equip a shop with many tools that can not be used full time. These figures are included here to emphasize the statement that since this new machine-tool equipment was installed—mostly during 1935—conditions have made it impossible to operate it at anywhere near its full capacity. However, of the new equipment installed in the present program, involving an expenditure of $227,000, the economies effected to date show a return of 11 per cent on the investment. In view of the fact that most of the new units have been in service considerably less than 12 months and have not been used to capacity this saving indicates that many of these new tools, if operated full time, will probably pay for themselves in from three to six years. Two of the installations, particularly, have already shown economies which, on a full time basis, will pay for themselves in less than one year. A still more important fact is that the Reading, by making this installation, has profited by relatively low machine-tool prices and has placed its locomotive repair shop in a position to keep down the expenses of machining operations as the shop work builds up toward a more nearly normal volume.

Conclusion

As stated at the outset two things of major importance have been accomplished at Reading Shop since 1932—a reorganization of the method of repairing locomotives has

Table III—Relative Percentages of Locomotive Repair Costs

	Labor	Material	Total
March, 1930	100.0	100.0	100.0
March, 1933	81.0	65.3	73.0
March, 1935	80.5	75.8	76.0

been effected and as a result of this change in method the need for modern facilities has been indicated and acted upon. In spite of curtailed operations a saving averaging 27 per cent in the number of working days required to put a locomotive through the shop has been effected. As to actual cost the figures in Table III give some idea of what has been accomplished. They are based upon actual labor and material costs of a number of Reading type 2-8-0 locomotives given Class 3 repairs in the months indicated.

Railroad Diesel Engineering*

By A. H. Candee†

External Regulation of Engine Output

Systems of control employing external regulating means for maintaining the generated output within the limits of engine power were developed to overcome some of the weaknesses of the differential control scheme. This external control has been accomplished in several ways, such as by a regulator which reflects engine speed (and thereby its loading), by faceplate rheostats operated in different ways, and by regulators governed by the output of the main generator. There are many such systems in successful operation today. Of these, the first system maintains the best engine loading over the widest range of train speed.

One of the disadvantages of differential control system is that the output of the main generator varies considerably with the temperature of the generating units. A low temperature exciter field winding results in high field current from the battery and therefore, high exciter voltages. This, coupled with low temperature main generator field windings, acts cumulatively to produce excess voltages for any value of motor current, with consequent overload on the engine. Actually, since the maximum fuel input to the engine is usually fixed to give full rated power and no more, the ultimate result is that the engine operates at a speed and power output lower than that for which it was applied. Another disadvantage of this control system is that both the main generator and the exciter operate with exceedingly variable voltages, so that there is no satisfactory source of power for battery charging and for operation of auxiliary equipment, unless a third machine is added and controlled to give relatively constant voltage over all ranges of engine speed and power demands of the traction motors. These disadvantages have been overcome in the externally regulated systems of control, since the excitation may be supplied from an auxiliary generator which delivers power at relatively constant voltage, and the output of the main machine is not dependent upon winding temperatures.

The foregoing has necessarily been a rather sketchy description of events which have led up to the adoption of Diesel power for railway propulsion and of the equipment involved in its use. It may readily be seen that to delve into the detail design of engines, transmission equipment, control, auxiliary apparatus, and of locomotives, rail cars and streamlined trains would extend this discussion beyond reasonable limits. It is proposed, therefore, to pass on to that phase of the engineering which deals with the application of this type of motive power to the various classes of railroad service for which it has been proven suitable and economical.

Why Railroads Use Diesel Power

The major reason for the application of Diesel motive power to railroad service is that it saves money. Of the eight expense sub-divisions—crew wages, fuel, lubrication, water, supplies, repairs, enginehouse expense, and fixed charges—six may be reduced by Diesel operation.

Lubrication is increased because of the consumption of lubricating oil by the engine itself, while fixed charges are necessarily increased because of the higher first cost of this type of equipment.

Diesel switching locomotives need but one man for their operation and the railroads often find it expedient to eliminate the fireman, thus saving a large percentage of the locomotive crew cost. In addition, it has invariably been found that Diesel motive power will switch faster than steam locomotives, so that the overtime may be reduced. Where crews are paid by the hour instead of for an eight-hour trick, the crew saving may be further increased.

Rail cars have been operated for years by one man with safety. It is often stated, however, that high-speed trains (such as streamlined trains) need two men in the operating cab for safety. While this is a moot point, it is firmly believed that one operator is sufficient for this type of train on most railroads, except some of the western roads.

The reduction in the number of men in a train crew may seem to impose a hardship on this group of railway employes, reducing the number of jobs open and thus throwing men out of work. When it is considered, however, that the railroads are fighting for their very existence against highly subsidized competition, the necessity of reducing expense is of vital importance not only to the railroad, but to the employes themselves. In the end, all employes thus displaced temporarily are reabsorbed by the natural attrition which is continually going on. The only place where this reduction in force is ultimately noticeable is in the new additions to the force to fill vacancies occasioned by retirements and other natural causes.

Fuel for Diesel power is usually much less expensive than for steam locomotives. In switching work this has been found to average 25 to 33 of that of steam operation (a 75 to 66 per cent reduction in this expense item). In rail-car service somewhat similar fuel savings may be effected, although there is a considerable variation between heavy and light trains.

Water and supply expense for steam power are relative small items as compared to total expense. Repair costs, on the other hand, are of major importance, and it has been rather definitely established that those for Diesel locomotives and rail cars are well below steam maintenance expense. Enginehouse expense is also much lower than for steam because ashpits, water facilities, and expensive fueling arrangements are unnecessary, likewise the labor of tending to the motive power during layover periods is a minimum.

Aside from the economies which result from the use of Diesel motive power in switching and rail-car services, other influences sometimes demand its use for special purposes. Among these are the elimination of coal smoke from metropolitan areas and operation in arid localities where water may be difficult to obtain.

In order to determine the proper size of Diesel engine required to handle a given service—switching, transfer,

rail car, streamlined train or road locomotive—it is necessary to have all of the operating information and service requirements. For most services, the total miles to be operated per run, the number of stops and slowdowns, stop time, the grade and curve data of the road, speed restrictions, train weights and consists, desired schedule speed, and similar information must be obtained. Switching service, having no definite runs of this nature, is analyzed in a different manner as described later.

The Speed-Time Curve

The speed-time curve forms the basis of all application studies. From data as indicated above, a continuous speed-time curve may be prepared for the whole run, which will show the performance throughout the whole operation. In general, however, such procedure is too long and tedious for commercial applications and a close approximation is made by dividing the whole run into various representative zones and plotting a typical run for each zone.

This may better be explained by following through an actual calculation for a rail car. Assume that one zone of this rail car service is 20.9 miles long, the elevation of the various points being as follows:

Station	Mile	Elevation	Rise	Fall
Harpersville	116.0	62 ft.		
Conway	123.5	180 ft.	118	
Mile 125.6	125.6	201 ft.	21	
Jordan	128.0	154 ft.		47
Mile 128.8	128.8	140 ft.		14
Wylie Center	132.4	220 ft.	80	
East Barton	136.9	184 ft.		36
			219	97

The equivalent grade, as determined by experience, may be taken as the sum of the rises in elevation less half of the sum of the decreases, divided by the number of hundred of feet of the zone (since per cent grade is the feet rise per hundred feet). This figure, then, 219 minus 48.5 (170.5 ft.) divided by 1103.52 or an equivalent grade of .155 per cent. This method assumes that only part of the descending grades are useful in gaining momentum for swinging up the next ascending grade. Also no track curvature is given because in this zone the curves are negligible. It is customary to estimate the average curvature over the whole distance and allow .8 lb. per ton of train weight as the resistance offered by curved track to train movement.

The steam schedule as now operated on this section of the run is 30.1 m.p.h. with one minute stop time per station. The train normally handled by a steam locomotive, consists of one 60-ton (loaded) baggage and mail car and three coaches averaging 65 tons each when loaded. The Diesel train would consist of one 100-ton (loaded) motor car with baggage and mail space plus the three trailers. From experience it may be estimated that 800 engine horsepower will be required to meet the schedule. The performance of such an 800-hp. car is as follows:

Miles per Hour	Tractive Force, lb.	Amperes per Motor
4	40,000	644
6.9	30,000	514
10	22,000	407
15	15,800	320
20	12,400	268
25	9,850	230
30	8,200	200
35	6,850	180
40	6,000	*220
45	5,300	*208
50	4,750	*197
55	4,300	*186
60	3,850	*175
65	3,400	*165
70	3,000	*152

* Motor fields shunted.

Likewise, the train resistance at various speed from the Davis formula (G. E. Review, October, 1926) is tabulated:

	Train resistance, pounds per ton		
Miles per Hour	Leading Car	Three Trailers	Total
6.9	360	700	1,060
10	360	700	1,060
15	410	730	1,140
20	470	785	1,255
25	565	840	1,405
30	655	910	1,565
35	755	990	1,745
40	880	1,070	1,950
45	1,025	1,155	2,180
50	1,170	1,250	2,420
55	1,330	1,360	2,690
60	1,520	1,480	3,000
65	1,720	1,580	3,300
70	1,930	1,700	3,630

From these data the speed-time curve may be plotted. Fig. 6 is a typical speed-time calculation sheet and Fig. 7 is the speed-time curve. A value of 100 lb. net tractive

RR Western Run Harp'ville - E. Barton Weg. 8432 Date 1/8/36

Weights		Equipment		Data Used		
Car	95 Tons	Eng. 1-800		Train Resistance Davis-Tabulation		
		Motors 4-571		Grade Resistance .155x20x290=900		
Trailing	195 Tons	G.R. 21-58 Wh 36		Curve Resistance 0		
				Total Resistance -		
Total	290 Tons	Curve Tabulation		Braking Rate .75 M.P.H.P.S.		

	Resistance								Motors	
M.p.h.	Train	Grade	Total	TF	Net TF	Accel.	dT	Sec	Amps.	Amps²
										(x10⁴)
0-6.9	1060	900	1960	30000	28040	.970		7.11	514	26.4
10	1060	900	1960	22000	20040	.690	3.74	10.85	407	16.6
15	1140	900	2040	15800	13760	.472	8.60	19.45	320	10.24
20	1255	900	2155	12400	10245	.353	12.11	31.56	268	7.19
25	1405	900	2305	9850	7545	.260	16.31	47.87	230	5.3
30	1565	900	2465	8200	5735	.198	21.83	69.70	200	4.0
35	1745	900	2645	6850	4205	.145	29.2	98.9	180	3.24
40	1950	900	2850	6000	3150	.109	39.3	138.2	220	4.84
45	2180	900	3080	5300	2220	.076	54.0	192.2	208	4.33
50	2420	900	3320	4750	1430	.049	80.0	272	197	3.88
55	2690	900	3590	4300	710	.024	137.0	409	186	3.46
59.5	2985	900	3885	3885	0	0	375	784	177	3.13

Run	Miles Lgth.	Sched. Speed	Seconds			Area		Total			
			Run	Stop	Tot.		Run	Amps²	Sec	RMS Amps.	Area
1	5.225	35	477	60	537	9.40	1	21	(10)6	198	4.02
2							2				
3		Adding 10% margin					3				
4		31.8			591		4				
5							5				

Sq. in. per mi. 1.8
Mi. per Sq. In. 20 x 100 + 3600 =1/1.8
Amps². Secs. per Sq. In. 100 x 50000 5(10)⁶

Calculated by A. H. C.

Fig. 6—Typical speed-time calculation sheet

force per ton of weight is assumed to produce an acceleration of one m.p.h. per second.

With the speed-time curve drawn, a planimeter is used to determine the time required for the typical run. From
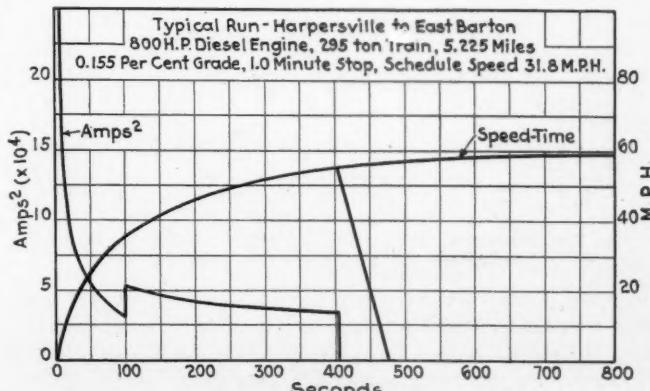
Fig. 7—Speed-time curve

the figures given, the average length of each individual run from station to station is found to be 5.225 miles, and from the calculations it is found that this requires 477 seconds running time, the train reaching a maximum

speed of 55 m.p.h. Adding the station stop time and allowing a 10 per cent margin for bad weather conditions and to permit making up time, this size of Diesel engine will haul this train over this profile at a schedule speed of 31.8 m.p.h., which is an improvement over steam operation.

To check the heating of the traction motors operating in this zone, the amperes drawn by each motor at each speed is tabulated and squared (to obtain heating value), then this squared value is plotted with the speed-time curve. Measuring the area and dividing by the total time of the run (477 running time plus 60-second stop) gives the mean squared current value, and extracting the square root gives the equivalent heating amperes for the run. This works out to be 198 amp., which is well within the continuous rating of the motor. Since the generator is applied to match the motor capacity, this is also within safe heating limits.

Analysis of Switching Performance

As has been indicated, there are no definite cycles of operating in switching service which may be calculated to determine the performance of Diesel power when applied to this work. If, however, the charac-
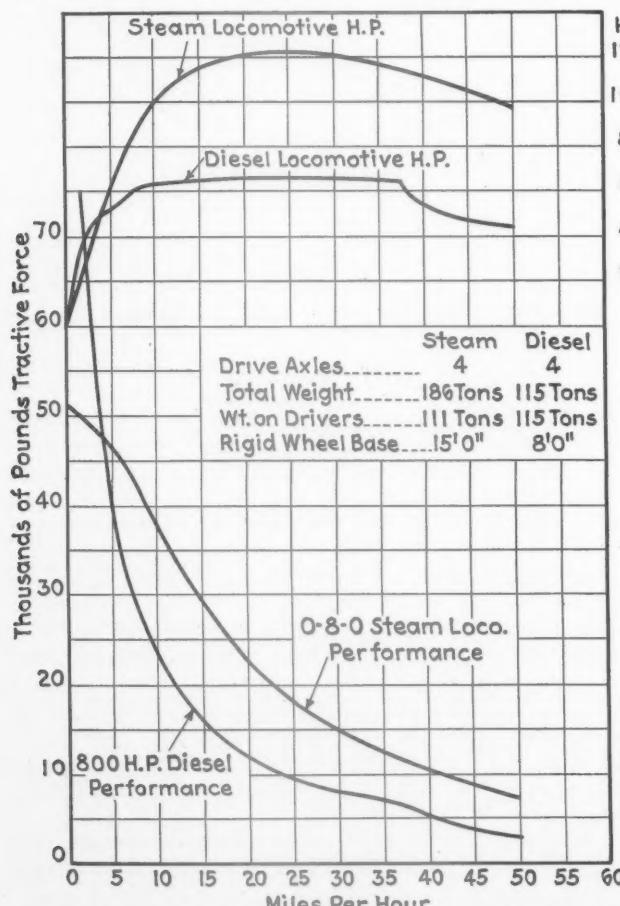
Fig. 8—Comparative characteristic curves of an 800-hp. Diesel locomotive and an 0-8-0 steam switcher

teristics of the steam power to be replaced are known, then the relative performance of the Diesel unit may be readily determined. By plotting speed-time curves of the steam locomotive pulling different weights of trains on level track and superimposing Diesel performance curves with the same weight trains, it will be noted that the Diesel has decidedly superior accelerating characteristics over the lower speed range, which offsets the improved steam performance over the higher speed range.

The curves shown in Fig. 8 are the actual performance curves of an 800-hp., 115-ton Diesel locomotive and an 0-8-0 steam switcher, the latter having the dimensions below:

```
Loaded engine weight.................................221,900 lb.
Loaded tender weight.................................150,700 lb.
Maximum tractive force...............................51,000 lb.
Factor of adhesion...................................    4.35
Rigid wheelbase .....................................  15 ft.
Steam pressure ......................................  175 ft.
Driver diameter .....................................  51 in.
Cylinder size .......................................22 in. × 28 in.
```

Consideration of these curves shows that the Diesel tractive force is superior to the steam below four miles an hour, but falls off considerably at the higher speeds. The
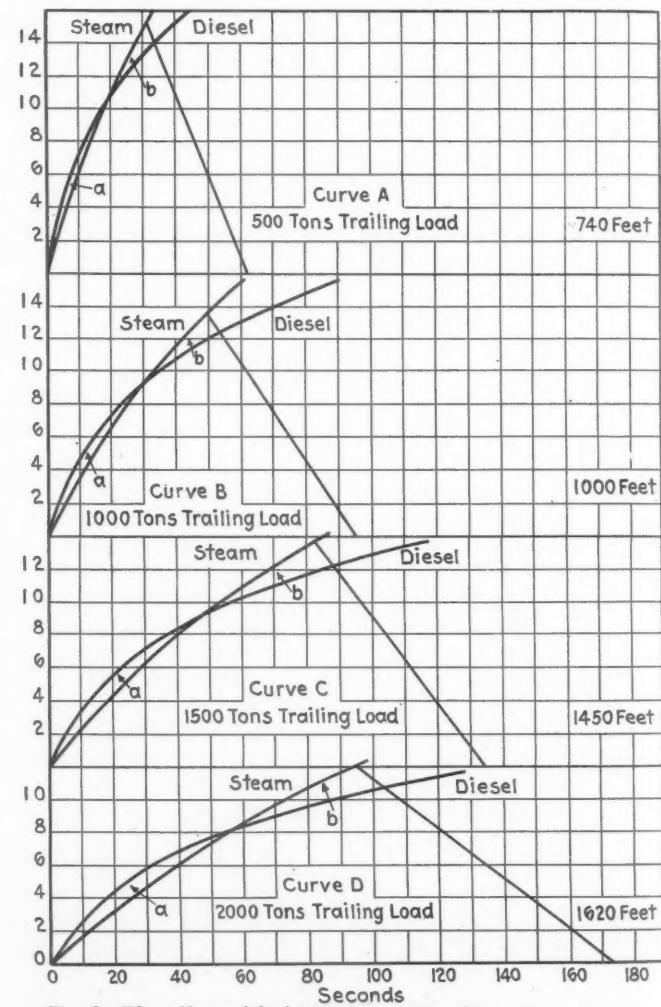

Fig. 9—The effect of high starting tractive force on acceleration

steam locomotive develops 1,220 hp., maximum, at the wheels while the corresponding Diesel output is only 657 hp.

The secret of the Diesel superiority lies in the high starting tractive force obtainable. Electric drive of the axle provides smooth and continuous application of torque, and reduces the tendency of wheels to slip, whereas the steam locomotive drive produces four distinct impulses at the wheels in each revolution. The minimum torque in a 90-deg. rotation of the wheels is 29.3 per cent less than the maximum during this same period. We have, therefore, a pulsating torque varying from 70.7 per cent to 100 per cent (with an average of 89.5 per cent) of the maximum available. Obviously, the useful tractive force of the electrically-driven wheels may be considerably higher (without exceeding the adhesive limit) than that of wheels driven by reciprocating engines through side rods. It has been

demonstrated in service that this may be 20 to 30 per cent greater than the useful steam tractive force for equivalent weight on drivers.

The effect of high starting tractive force in the acceleration of a train is shown in Fig. 9. Curves *A, B, C* and *D* are for different train weights, showing the accelerations as obtained by the Diesel locomotive with its relatively high initial tractive force, and as obtained by the steam locomotive. The Diesel locomotive has the advantage in each case, this superiority being evidenced by higher speeds up to 8 or 10 m.p.h., which is the point where the steam and Diesel acceleration curves cross. This, however, is only a part of the
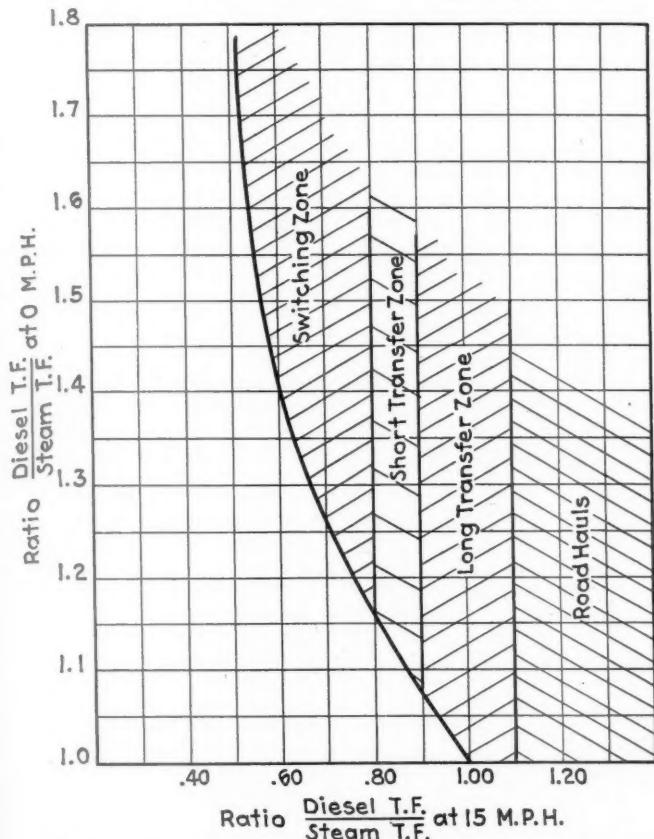
Fig. 10—Approximate guide for the selection of Diesel switcher size

analysis. Area on each of these curves represents distance moved (miles per hour multiplied by time), and it may be noted from these charts that the area under the Diesel curve up to the crossing point is considerably greater than that under the steam curve. In other words, if the two equal trains started side by side, the Diesel train would be a considerable distance ahead of the steam train when they reached the same speed. If then, the steam train is to catch up to the Diesel train, it must move faster than the Diesel to regain the area (distance) lost up to 8 or 10 m.p.h. The two locomotives continue until the area *b* is equal to the area *a*. If both are then braked to a stop at the same rate, they will come to rest at the same point. Measuring the areas, it is found that the length of runs for which these locomotives give equal performance are: 500-ton trailing load, 740 ft.; 1,000-ton trailing load, 1,000 ft.; 1,500-ton trailing load, 1,450 ft.; 2,000-ton trailing load, 1,620 ft.; and that on all runs shorter than these the Diesel is actually faster.

The average length of run in yard service as recorded for 21,750 movements on 12 different railroads is 582 ft., and the average trailing load is 306 tons. The curves indicate, therefore, that the 800-hp. Diesel locomotive

can perform faster than the 0-8-0 steam locomotive in practically any normal yard operation.

Comparisons such as just shown have been made for a great many locomotives. In order to derive a quick method of selecting a Diesel locomotive to replace a known steam locomotive in switching service, a curve as shown by Fig. 10 has been drawn. By plotting the ratio of starting tractive forces of the two units and the ratio of tractive forces at 15 m.p.h., account has been taken of the Diesel starting advantage and of the higher steam power at higher speeds.

One factor which enters into the application of Diesel switching motive power is that of the short time rating of the electrical equipment. Conditions are often encountered where the locomotive has a heavy train and a stiff grade to negotiate in making a transfer movement. To provide ready means of checking the approximate limitations of the motors and the generator from a safe heating standpoint, a curve has been prepared for each locomotive size, one of which is shown by Fig. 11. For instance, if in a transfer movement the grade starting out of the yard is 0.6 per cent for three miles, the permissible train which may be han-
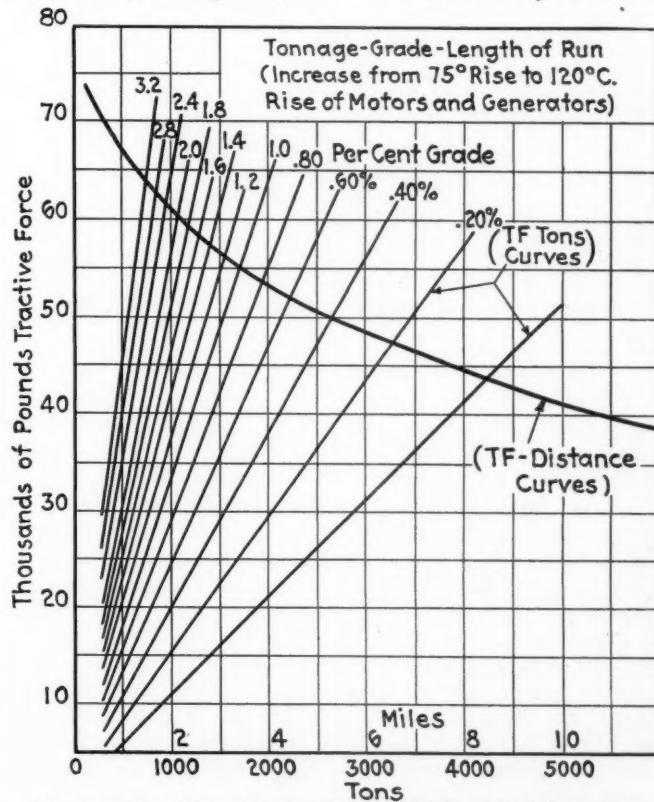

Fig. 11—Short-time operating limits—1600-hp. Diesel locomotive

dled is determined by starting at the three-mile point and going vertically to the T. F.—Distance curve. Then by horizontal translation to the grade line and from there down to the base line again it will be found that 2,450 tons may be safely handled. This, of course, assumes that the motors start this run at a temperature not exceeding 75 deg. C above ambient temperature. Actually, switching service is so varied and requires so little work from the traction motors that the motors usually start a run of this nature at a much lower temperature.

The calculation of a curve such as Fig. 11 requires a knowledge of the time-temperature characteristics of the electrical machinery. Unfortunately, in the production of commercial motors and generators, elaborate tests may not always be made because both time and

expense must be conserved while calculations alone will not give the data required. However, from a few tests made on different motors, Fig. 12 was prepared to show the approximate time rating of railway motors such as are used on Diesel locomotives. Since the fundamental basis for the calculation of Fig. 11 is approximate, it may readily be seen that this should be used with care.

Streamlined Train Application

The predetermination of engine size and train performance of a unit train involves a number of new factors upon which there is little verified data. This is based upon such trains being constructed with aerodynamically designed exteriors, of extremely light weight,
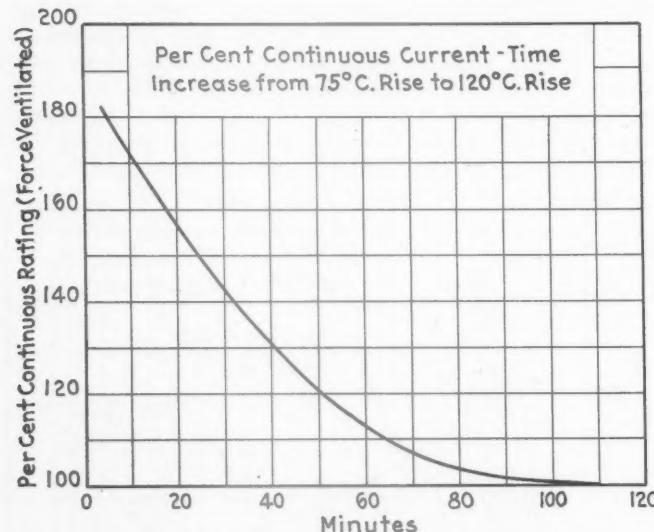
Fig. 12—Estimated railway motor time—temperature curve

articulated car bodies, and for high-speed operation. The most vital consideration is the air resistance to be used in calculating the performance.

There have been many tests carried out for the purpose of deriving constants by means of which streamlined train resistance may be calculated. A series of articles published in the *Railway Mechanical Engineer* issues of August, September, and October, 1934, covers a great many tests which have been made, but still leaves us without a practical formula for commercial application work. Most engineers, however, are familiar with the Davis formula, and so this is generally used as the basis for streamlined train resistance estimates, modifying the constants to allow for the aerodynamic improvement.

The Davis formula is:

$$\text{Resistance} = 1.3 + \underbrace{\frac{29}{W}}_{\left\{\begin{array}{c}\text{Journal}\\\text{Friction}\end{array}\right\}} + \underbrace{0.045V}_{\left\{\begin{array}{c}\text{Flange}\\\text{Resis.}\end{array}\right\}} + \underbrace{\frac{K}{WN}AV^2}_{\left\{\begin{array}{c}\text{Air}\\\text{Resis.}\end{array}\right\}}$$

W = Tons per axle
V = Speed in miles per hour
N = Number of axles
A = Frontal area of train in square feet
K = Windage constant:
      0.0024 for conventional type head car
      0.00034 for conventional type trailers.

Experience has indicated that for streamlined trains the values of K may be reduced to the following values, which are from 40 to 60 per cent of standard values.

For head-end car .... .00096 to .00144
For trailers .... .000136 to .000204

Since the application engineer must make no mistake in applying a train of this nature, costing hundreds of

thousands of dollars, it is almost imperative that the higher values of K be used.

Fig. 13 is shown to indicate the relative train-resistance values between conventional types of cars and streamlined trains. This is for a train such as the New Haven "Comet."

With the train resistance determined, the rest of the calculations are similar to those of a conventional train. However, since the power required for auxiliary purposes is high (air conditioning and lighting loads are large), care must be taken to determine the real power available from the engine for propulsion purposes.

In an effort to reduce the amount of work necessary in applying Diesel equipment to high-speed trains, it has often been found expedient to plot a typical curve of the accelerating characteristics from start to balancing speed, or the permissible speed limit if this is lower than the balancing speed. By drawing in the braking lines from the maximum speed to lower speeds and using a planimeter to measure the areas, the distance (and hence the time) lost each time the train speed is reduced and re-accelerated may be determined. Then, by taking the full-speed time between terminals and adding the time required for each slowdown, for each mile of slow-speed operation, and the station time for each stop, the total running time may be approximated.

The curve shown by Fig. 14 indicates the method of plotting the acceleration and braking curve. The full-speed mileage, slowdowns, and slow running zones of the run for which this curve was prepared are tabulated:

Miles	M.p.h.
343.55	90
32.75	80
1.75	75
8.00	70
7.50	60
2.65	40
1.50	30
1.15	25
1.00	20
.15	15

No. of slowdowns from 90 m.p.h.	
6	80
8	75
5	70
2	60
6	50
1	45
5	40
1	30
3	25
1	20
1	15
7	0

6 intermediate stops of 2 min. each

From Fig. 14 the time lost per slowdown has been determined. Likewise, the time lost per mile of slow running at different speeds has been figured. This is:

Slowdown to, and restoration from m.p.h.	Time lost, min. (per slowdown)
80	.27
75	.47
70	.68
60	1.13
50	1.47
45	1.70
40	1.87
30	2.15
25	2.35
20	2.50
15	2.65
0	3.00

Running at m.p.h.	(Per mile)
80	.09
75	.14
70	.20
60	.34
40	.84
30	1.34
25	1.74
20	2.34
15	3.34

By this method it may be determined that the total time of the run is 361.58 minutes, or a scheduled speed of 66.3 m.p.h. This is figured by adding the lost time to that required if the whole run were at 90 m.p.h., as follows:

Miles	Speed, m.p.h.	Running time, min.
400.00	90	267.00
32.75	80	*2.95
1.75	75	.25
8.00	70	1.60
7.50	60	2.55
2.65	40	2.23
1.50	30	2.01
1.15	25	2.00
1.00	20	2.34
.15	15	.38
Stop time		12.00
Time		295.31

No.	—Slowdowns— to m.p.h.	
6	80	1.62
8	75	3.76
5	70	3.40
2	60	2.26
6	50	8.83
1	45	1.70
5	40	9.35
1	30	2.15
3	25	7.05
1	20	2.50
1	15	2.65
7	0	21.00
Total time of run		361.58

* These and the figures following are the time in excess of that required to make the same distance at 90 m.p.h.

Diesel Locomotives for Road Hauls

One reason for the improvement of switching service by Diesel motive power is the fact that the time out
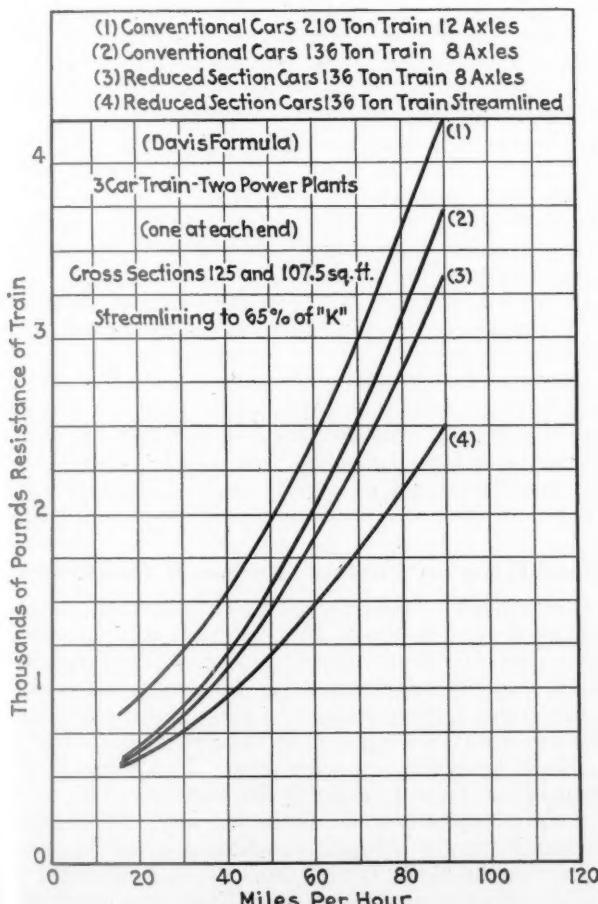
Fig. 13—Train resistance values of conventional three-car train and three-body-unit train

of service for fueling, inspection, and repairs is much less than for steam, thus giving a higher availability factor. Where Diesel locomotives are used for hauling freight or passenger trains, the scheduling of trains limits the amount of time of Diesel use per day. It has also been determined that as the sustained load on the locomotive increases, the relative difference between steam fuel and Diesel fuel decreases. In other words, the advantages of Diesel power decrease with the heavier trains and longer hauls, whereas the purchase price differential increases and the higher fixed charges eat heavily into the savings effected. For this reason the main line Diesel locomotive may not yet be considered competitive with steam, although there are a number of tests being carried on at present to determine the exact field for such units.

Savings by Diesel Motive Power

With the size of engine and equipment determined for a given service and its performance known, the engineer may next prognosticate the operating costs. To do this, however, requires a background of accumulated
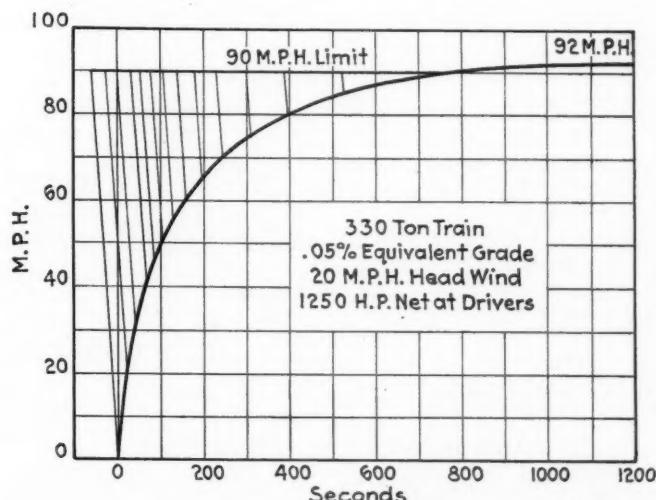

Fig. 14—High-speed train accelerating curve

service and cost information. Because of the voluminous character of these data they may not be included here, but typical cost comparisons as derived from such data are presented.

The first tabulation is that of an actual study where it is proposed to use baggage-mail rail cars, each equipped with a 1,060-hp. engine, hauling from four to six trailing cars. Two such cars will handle four runs, making a total of 168,000 miles per year (84,000 miles per car).

TYPICAL RAIL-CAR COST COMPARISON

Expense item	Dollars per month Steam	Diesel
Wages, engineman	$1,008.16	$1,008.16
Wages, fireman	746.62	....
Wages, conductor	728.24	728.24
Wages, baggageman	510.80	510.80
Wages, flagman	506.69	*........
Fuel	1,730.74	786.50
Power equipment repairs	2,833.42	1,305.72
Water	216.00	....
Lubrication	110.26	188.64
Enginehouse expense and miscellaneous	66.74	42.07
Train supplies	416.59	416.59
Car repairs	1,244.14	1,419.81
	$10,118.40	$6,406.53

Operating expense per year	$121,421.00	$76,878.00
Savings per year by Diesels	....	44,543.00
Savings, approximate per cent on net investment	....	20

* It has been customary to reduce train crew on motor-car trains by eliminating the flagmen.

This comparison does not include fixed charge because it was desired to determine the time in which the investment could be completely written off of the books by applying all of the savings for this purpose. As may be noted, this will take slightly over five years.

The operating savings by the use of Diesel switching locomotives are shown by the tabulation which follows. In this comparison are shown the present cost of operating old steam power, the reduction in cost effected by the purchase of new (improved) steam locomotives, and by the use of Diesel locomotives. There has been a concerted drive by some of the steam-locomotive manufacturers to try to stem the rising tide of Diesel substitutions by proposing such new and improved steam power, but the total savings by Diesels so far outweigh those of new steam that such a campaign has had little effect.

TYPICAL SWITCHING COST COMPARISON

	Old steam	New steam	Diesel
Regular hours	28,848	28,848	26,553
Overtime hours	1,389	1,389	347
Wages, straight time:			
Enginemen	$26,194.27	$26,194.27	$24,163.23
Firemen	20,530.29	20,530.29	....
Foreman	25,436.43	25,436.43	23,368.84
Switchmen	51,582.38	51,582.38	47,529.87
Total	$123,743.37	$123,743.37	$95,061.91
Wages, overtime:			
Enginemen	$1,980.62	$1,980.62	$494.47
Firemen	1,541.52	1,541.52	....
Foreman	1,918.69	1,918.69	478.86
Switchmen	4,074.10	4,074.10	1,016.71
Total	$9,514.93	$9,514.93	$1,990.04
Fireman allowance for cleaning fires	$913.36	$913.36	....
Total crew wages................	134,171.66	134,171.66	$97,051.95
Coal—10,803 tons	42,347.76	31,760.82	....
Oil—163,000 gals.	....	....	8,150.00
Water	1,230.89	923.17	....
Repairs	18,685.01	15,882.26	14,079.07
Enginehouse:			
Labor	19,168.03	19,168.03	11,596.66
Supplies	1,165.52	1,165.52	769.30
Lubricants	828.75	828.75	1,956.00
Other supplies	376.34	376.34	376.34
Total	$217,973.96	$204,276.55	$133,979.32
Savings over old steam..........	....	$13,697.41	$83,994.64
Savings over new steam.........	....	....	70,297.23

Discussion of Empirical Data

It is a surprising fact that of all the data and figures used in the engineering of Diesel motive power, electrical equipment characteristics alone permit of prognostication of the performance with a reasonable degree of certainty. Engines, radiation, lubricating oil characteristics, mechanical designs, ventilation, application to specific or general services, and economic studies all involve many variables and incalculable factors which experience alone can solve.

It has been pointed out that train resistance values and constants are a result of experience. It may also be noted that with a side or quartering wind the flange resistance will change materially, and that type of journal bearings, shape of cars, barometric pressure and many other factors alter the resistance to movement. It is probable that no formula will ever be developed to account for all of these varying factors, and were such a formula derived it would be too complicated to be of commercial value.

The determination of steam locomotive speed-tractive force characteristics is essential in comparing the relative performance of steam and Diesel motive power. In order to calculate such a curve, the following must be assumed: 55 pounds of water are evaporated per hour for every square foot of direct heating surface; 8 to 13 pounds of water are evaporated per hour for every square foot of tube and flue heating surface; 15.25 to 35 pounds of steam per hour generate one horsepower-hour, depending upon boiler pressure and degree of superheat. These figures assume ideal conditions of firing, correct adjustment of cutoff, clean tubes and flues,

and represent optimum performance. Actually, the road performance may be anywhere from 65 to 90 per cent of this. The proper performance to be assumed, then, in making a comparison is a matter of judgment, but is normally assumed to be 75 per cent of the theoretical curve, with the low speed operating range discounted even more than this.

In studying a profile to determine the "equivalent" grade for any zone of operation, it has been shown that we add the rises in feet and subtract half of the falls in feet in order to obtain an equivalent total rise. This is purely empirical and represents values which have been found reasonable to permit a close prognostication of a schedule. It may be readily seen that if all of the station stops happen to be located at the bottom of the grades so that advantage may not be taken of the accumulated momentum, or if speed is restricted on the down grade portions of the run, the assistance of these down grade sections in getting over the profile may be negligible and the equivalent grade will be higher. On the other hand, other profiles may permit full use of these descending grades and the equivalent grade lowered. This requires judgment and experience.

In considering the performance of a locomotive on varying grades, the transition of the train from one grade to the other is gradual and the rate of transition depends upon the length of the train and its speed. It has been found expedient to consider such trains as being concentrated at a single point, and only in special cases are the calculations based upon this gradual transition.

As has been pointed out earlier in this paper, the short-time thermal characteristics of electrical equipment are not well known, due to the commercial urge of quick production at limited expense. Road experience has been found to be of considerable value in determining motor and generator sizes suitable for the extremely variable conditions met in railway service. As an example of this, it has been found that for general railroad switching work it is necessary to apply motors having a continuous rating of 225 lb. per ton of locomotive weight in order to be large enough to handle the peak demands encountered. If motor developments of the future improve the ratio of continuous rating to short-time rating, then it will be necessary to revise this figure of 225 lb. per ton.

In the manufacture of Diesel railway equipment, most of the work is of a mechanical nature, even in the electrical equipment. It is surprising to an electrical engineer to find how inexact are some of the data and knowledge used in such mechanical designs. Allowable stresses, physical characteristics of materials, clearances, finishes, growing of castings, and similar necessary design information are frequently guessed and then proved out by actual road operation.

Possibilities of Further Technical Development

It is possible to look forward to considerable improvement in design, methods, and materials which enter into the design of Diesel motive power. The progress of this art will be accelerated by developing more power from a given engine, lower cost of engines, smaller electrical transmission equipment, lower transmission cost and such economic improvements. The method of obtaining these improvements is not known at this time or such developments would be under way. It is possible to visualize many advances, such as a lower resistance-conducting medium, better properties of magnetic materials, higher engine speed, etc. There are many minds working on these problems, and out of this will undoubtedly come ideas of considerable value.

Designing for

High-Tensile Steels[*]

Bending

The stress due to bending moment is given by the fundamental equation:

$$f = \frac{M}{S} \quad \dots \dots \dots \dots \dots \dots \dots \dots (5)$$

in which

f = Unit stress, lb. per sq. in.
M = Moment, in.-lb.
S = Section modulus, in.^{3}

In comparing two designs for the same bending moment, $f_1 S_1 = f_2 S_2$, from which is readily derived the relation:

$$S_2 = \frac{f_1}{f_2} S_1 \quad \dots \dots \dots \dots \dots \dots (6)$$

The ratio of f_1/f_2 may be obtained from the nomograph in Fig. 1.

Let the cross-section of a plate, subjected to bending, be that shown in Fig. 5(a).

$$I = \frac{bt^3}{12} \quad \dots \dots \dots \dots \dots \dots \dots (7)$$

$$S = \frac{bt^2}{6} \quad \dots \dots \dots \dots \dots \dots \dots (8)$$

Keeping b constant and combining equations (6) and (8),

$$t_2 = \sqrt{\frac{f_1}{f_2}} \times t_1 \quad \dots \dots \dots \dots \dots (9)$$

The nomograph in Fig. 6 gives the graphical solution of the ratio under the radical. A few values are given in Table VII.

Table VII—$\sqrt{\dfrac{f_1}{f_2}}$

f_2	$f_1 = 16,000$	$f_1 = 18,000$
21,000	.873	.926
24,000	.816	.866
25,000	.800	.848
26,000	.784	.832
27,000	.770	.816
28,000	.756	.802
29,000	.743	.788
30,000	.730	.775

As an example, it is seen that the use of a unit stress of $f_2 = 24,000$ lb. per sq. in. requires a thickness of plate equal to .816 of that with a unit stress of $f_1 = 16,000$ lb. per sq. in. This effects a reduction of 18.4 per cent in the thickness and consequently the same reduction in the weight of steel required.

Another case of bending on a plate is that of the cross-section in Fig. 5(b).

$$I = \frac{bd^3}{12} \quad \dots \dots \dots \dots \dots \dots (10)$$

$$S = \frac{bd^2}{6} \quad \dots \dots \dots \dots \dots \dots (11)$$

Combining equations (6) and (11), with depth d constant:

$$b_2 = \frac{f_1}{f_2} b_1 \quad \dots \dots \dots \dots \dots \dots (12)$$

Reference may be made to Fig. 1 for values of the ratio f_1/f_2.

By H. M. Priest†

Comparisons of weight, strength and deflection characteristics of high-tensile-steel and carbon-steel structures. Method for cost comparisons is also suggested

An interesting and practical question arises as to the effect of increased unit stresses upon the area of the flanges of beams and girders. Two typical flanges are shown in Fig. 5(c). Let

A = Area of one flange, sq. in.
d = Distance between centers of gravity of flanges, in.
f = Unit stress in the flanges, lb. per sq. in.
M = Moment carried by the flanges, in.-lb.

Then

$$A = \frac{M}{fd} \quad \dots \dots \dots \dots \dots \dots (13)$$

For the basic and new designs respectively:

$$A_1 = \frac{M}{f_1 d_1}, \text{ and } A_2 = \frac{M}{f_2 d_2}$$

Assuming that

$$d_1 = d_2$$

$$A_2 = \frac{f_1}{f_2} \times A_1 \quad \dots \dots \dots \dots \dots (14)$$

It will be observed that this equation is the same as Equation (2) for tension members and the ratio may be solved by means of the nomograph in Fig. 1.

If the plate of Fig. 5(b) is combined with the flanges
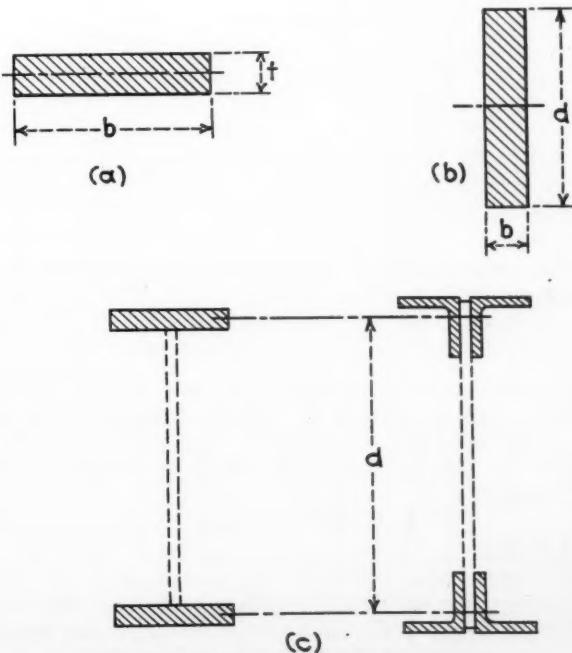
Fig. 5—Sections resisting bending stresses

243

of Fig. 5(c) to form a plate girder it will be seen from a consideration of Equations 12 and 14 that, with a constant depth, the total areas are related by the equation, $A_2 = f_1/f_2 \times A_1$. The saving in weight of the beam or girder, as represented by this equation, may be said to be the maximum possible, for the reason that other considerations, such as web crippling, shear and
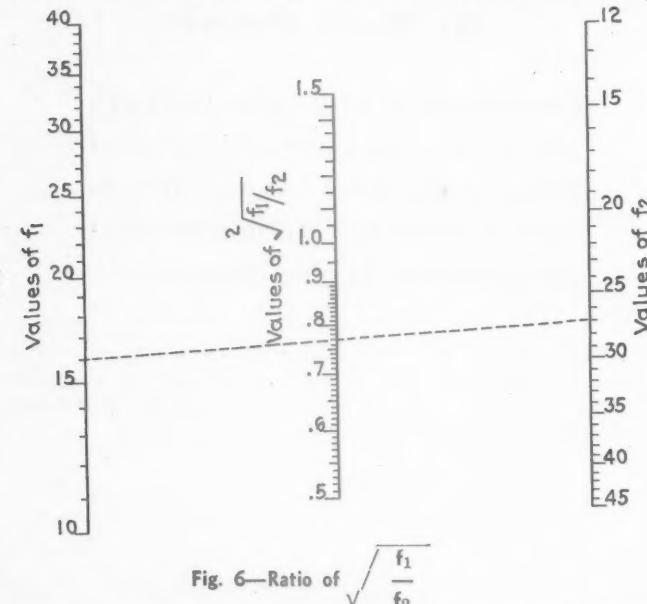

Fig. 6—Ratio of $\sqrt{\dfrac{f_1}{f_2}}$

lateral buckling may limit the reductions or add weight in the form of stiffeners which will offset some of the saving indicated. These factors will be treated more fully in a later portion of this paper.

A study of weights of wide flanged beams (CB Beams) was made by first selecting the minimum weight of beams required for each of 74 different values of section modulus, ranging in value from 20.0 to 704.5, each value being 5 per cent greater than the preceding one. With these values equal to S_1 in Equation (6), the values of S_2 were calculated for several ratios of f_1/f_2 for which the most economical weights of beams were selected. The comparison of weights is given in Table VIII.

Table VIII

Ratio $\dfrac{f_1}{f_2}$	Ratio of weights
1.00	1.000
.90	.934
.80	.865
.70	.796
.667	.771
.60	.720
.50	.643

The ratio of weights is very closely represented by the formula

$$\text{Ratio} = .70\,\frac{f_1}{f_2} + .30 \quad\quad\quad (15)$$

An example will illustrate the use of this formula. Assume that the saving in weight of beams is desired when the working unit stress is raised from 16,000 to 24,000 lb. per sq. in. The ratio of weights equals $.70\left[\dfrac{16,000}{24,000}\right] + .30 = .767$, showing an average saving of 23.3 per cent.

It is possible to obtain a greater saving for the cases shown in Figs. 5(a), 5(b) and 5(c) by corrugating the sheet or plate in the first case and by increasing the

depth d for the last two cases. These methods of securing weight reduction are applicable to the basic design as well as to the new design, but they should not be overlooked when making a study of possible weight economies.

The reduction in thickness of the web of a beam or plate girder designed for high-tensile steel makes it necessary to give special attention to this feature. In a paper entitled Stability of the Web of Plate Girders,[5]

Table IX—Limiting Values of $\dfrac{h}{t}$

Tension yield point, lb. per sq. in.	Shearing yield point, lb. per sq. in.	Max. $\dfrac{h}{t}$
29,000	18,000	88.2
33,000	21,000	81.7
45,000	29,000	69.5
50,000	33,000	65.1
55,000	37,000	61.5

by S. Timoshenko, there is an excellent discussion of the problem.

A further discussion of this paper by O. E. Hovey appeared in Bulletin 374 of the American Railway Engineering Association for February, 1935, in which modifications are suggested to bring the formulae and tables of the paper into more convenient form.

Two conditions of stress are considered: one, a rectangular plate subjected to pure shear, as at the ends of a girder; the other, that of a rectangular plate sub-

Table X—Maximum Values of $\dfrac{h}{t}$

Tensional yield point, lb. per sq. in.	Values of $\dfrac{h}{t}$
29,000	182.1
33,000	170.7
45,000	146.1
50,000	138.6
55,000	132.2

jected to bending, as at the center of a girder. S. Timoshenko shows that the critical shearing stress for a web without stiffeners has the value

$$S_{cr} = 4.83\,E\,\frac{t^2}{h^2} = F\,S \quad\quad\quad (16)$$

from which the limiting maximum values of h/t are given by the formula

$$\frac{h}{t} = \sqrt{\frac{4.83E}{S_{cr}}} = \sqrt{\frac{4.83E}{FS}} \quad\quad\quad (17)$$

S_{cr} = Critical unit shearing stress, lb. per sq. in.
h = Clear distance between flanges, in.
t = Thickness of web, in.
S = Working unit shearing stress, lb. per sq. in.
F = Factor of safety.

The results of tests show shearing yield points approximately as given in Table IX from which values of h/t have been calculated from Equation (17).

These limiting values are those for unstiffened webs with the maximum unit shearing stresses. The specifications of both the American Railway Engineering Association and the American Institute of Steel Construc-

tion contain the following type of clause for carbon steel of structural grade, (quoted from the A.R.E.A. Specifications for Steel Railway Bridges):

If the depth of the web between the flanges or side plates of a plate girder exceeds 60 times its thickness, it shall be stiffened by pairs of angles riveted to the web.

Similarly, for alloy steels with tension yield points of 45,000 and 50,000 lb. per sq. in., the A.R.E.A. Specifications require stiffeners when the ratio of the clear depth to thickness of the web exceeds 50 times the thickness.

The spacing of stiffeners may be obtained from the formula[6]:

$$d = \frac{255,000}{S} t \sqrt[3]{\frac{St}{a}}. \quad \text{...................(18)}$$

S = Unit shearing stress on gross section of web at point considered.
t = Thickness of web.
a = Clear distance between flanges.
d = Clear distance between stiffeners.

Equation (18) is applicable to steel of various grades. The dimensions are clearly illustrated in Fig. 7(a).

The minimum thickness of web is usually determined by the conditions prevailing near the center of the girder span where the web is subjected to the maximum mo-

(a)

Section "A-A"

Neutral Axis

Compression

Stress Diagram

(b)
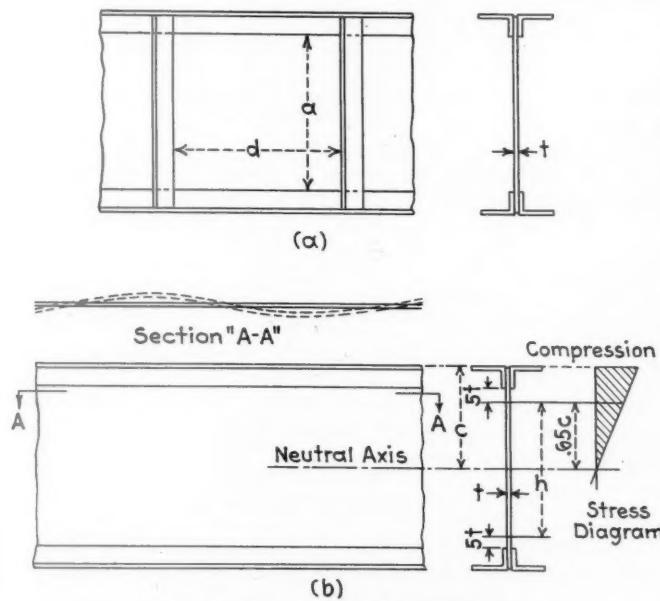
Fig. 7—Stability of girder web plates

ment. The web, just inside the compression flange of the girder shown in Fig. 7(b) is under a large compressive stress and tends to buckle as illustrated in Section AA. The critical buckling unit stress is given by the following formula in the paper on web stability by S. Timoshenko:

$$S_{cr} = K \frac{E}{1 - m^2} \frac{t^2}{h^2}. \quad \text{.....................(19)}$$

S_{cr} = Critical buckling unit stress, lb. per sq. in.
K = Constant
E = Modulus of elasticity, lb. per sq. in.
m = Poisson's Ratio
t = Thickness of web, in.
h = Clear distance between flanges, in.

Letting S_{cr} = Tensional yield-point stress, K = 19.7, m = 0.30 and E = 29,000,000 and solving for h/t,

$$\frac{h}{t} = \frac{25,000}{\sqrt{YP.}}. \quad \text{..........................(20)}$$

O. E. Hovey made a study of railway plate girders in which he assumed that the flanges supported the web for a distance from the flanges equal to five times the

thickness of the web—see Fig. 7(b). He found that this point is about 0.65 of the total distance from the neutral axis to the extreme fibre of the flange. Hence the compressive stress at this point is 0.65 of the maximum stress. With the maximum stress equal to the tensional yield-point stress, the critical stress in Equations (19) and (20) may be placed equal to 0.65 times the yield point, resulting in the formula:

$$\frac{h}{t} = \frac{25,000}{\sqrt{.65YP.}} = \frac{31,000}{\sqrt{YP.}} \quad \text{...................(21)}$$

Equation (21) yields the values of h/t for several different yield points given in Table X.

It is readily seen that the high-tensile steels have lower limiting values for the ratio, h/t, than that for carbon steel. When necessary, the web may be strengthened by means of horizontal stiffeners but this is apt to be a rather expensive method and the less costly way may be that of increasing the web thickness to meet the requirements in Table X.

It should be remembered that the buckling of a girder web does not necessarily mean failure of the web. The diagonal tension in the web and the compression in the vertical stiffeners or struts will transform the action of the girder into one analogous to that of a Pratt truss. Girders may be designed upon this basis, as is sometimes done in metal airplane construction, but especial attention must be given to the flanges and their connection to the web in order to provide properly for the bending of the flanges between the stiffeners.

When the compression flange of a beam or girder is unsupported laterally it is necessary to decrease the allowable unit stress in order to prevent the flange from buckling in much the same manner as a column. This is not a subject which lends itself readily to exact analysis, nor are there many test data against which to check any theoretical formulae. It was shown in the section of this paper dealing with compression that a theoretical analysis of a compression member leads to the secant formula. This same method of analysis will be applied to the problem of compression flanges.

The general formula for the working unit stress in compression may be written as follows:

$$\frac{P}{A} = \frac{\frac{Yield\ Point}{m}}{1 + a \sec \sqrt{\frac{mP}{AE}} \left[\frac{L'}{2r} \right]} \quad \text{.............(22)}$$

in which m = factor of safety and the other terms are as previously noted. In order to reduce this formula to workable form it is necessary to assign values to the several terms.

The factor of safety will be taken between values of 1.81 and 1.87, varied slightly for the several yield points in order to bring the numerator of the right-hand member of the equation into round thousands of pounds per square inch:

Yield point, lb. per sq. in.	Factor of safety	Unit stress, lb. per sq. in.
29,000	1.813	16,000
33,000	1.833	18,000
45,000	1.875	24,000
50,000	1.852	27,000
55,000	1.833	30,000

Existing formulae for compression flanges generally use the ratio of unsupported length to width of flange, L/b, instead of the familiar ratio of L/r for columns and compression members. A study of beam and girder flanges indicates that for a general average the lateral

radius of gyration may be taken as equal to 0.25 of the width of the flanges, i.e., $r = .25b$.

The formula to be derived will be based upon uniformly loaded beams and girders of simple span with flanges unsupported between vertical supports. For this condition of loading the effective length of the flange, acting as a column, may be taken as 0.694 times the total length; that is, $L' = 0.694L$.

The remaining term of the formula which must be given a value is a, the eccentric ratio. A reasonable value for this term is $.005L/b$. When $L/b = 0$, the value of P/A equals the unit stress obtained by dividing the yield point by the factor of safety. The usual maximum limit for L/b is taken at 40, at which value a would equal 0.20. This is somewhat under the value of 0.25 recommended for columns by the A.S.C.E. Special Committee on Steel Column Research, and in view of the existence of some lateral support in every beam or girder, the assumption of $.005L/b$ for the eccentric ratio is a reasonable one.

Assembling these terms and placing them in Equation (22) there is obtained

$$\frac{P}{A} = \frac{\dfrac{\text{Yield Point}}{m}}{1 + .055\dfrac{L}{b}\sec\sqrt{\dfrac{mP}{AE}}\left[\dfrac{.694L}{.25b}\right]}$$

A reference to Fig. 3 shows that the curve plotted for the secant formula reverses from a curvature convex upward to convex downward. For the above formula the point of reversal of curvature occurs in the vicinity of $L/b = 40$ for yield points of 29,000 and 33,000 lb. per sq. in. and of $L/b = 35$ for the yield points of 45,000, 50,000 and 55,000 lb. per sq. in. These limits for L/b will be used, within which the formulae will be applicable.

As an example, let us take the case of the yield point equal to 33,000 lb. per sq. in. and the factor of safety equal to 1.833. Let the modulus of elasticity equal 29,400,000 lb. per sq. in.

$$\frac{P}{A} = \frac{18,000}{1 + .005\dfrac{L}{b}\sec\sqrt{\dfrac{1.833}{29,400,000}\dfrac{P}{A}}\left[\dfrac{.694L}{.25b}\right]}\ \dots\dots(23)$$

This is a complicated formula from which to obtain the value of P/A and, as in the case of column formu-

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Table XI—Allowable Compressive Unit Stresses—Unsupported Flanges

Yield point, lb. per sq. in.	$\dfrac{P}{A}$	Range for $\dfrac{L}{b}$
29,000	$16,000 - 4.36\left[\dfrac{L}{b}\right]^2$	0 — 40
33,000	$18,000 - 5.34\left[\dfrac{L}{b}\right]^2$	0 — 40
45,000	$24,000 - 9.31\left[\dfrac{L}{b}\right]^2$	0 — 35
50,000	$27,000 - 11.25\left[\dfrac{L}{b}\right]^2$	0 — 35
55,000	$30,000 - 13.27\left[\dfrac{L}{b}\right]^2$	0 — 35

---

lae, a simple parabolic formula can be substituted for the portion of the secant curve which lies between $L/b = 0$ and the maximum limit previously mentioned. In this example such a parabolic formula is:

$$\frac{P}{A} = 18,000 - 5.34\left[\frac{L}{b}\right]^2$$

Similarly, for a few other values of the yield point, the parabolic formulae are given in Table XI.

The values given by these various formulae are plotted in Fig. 8. The curves for yield points of 45,000, 50,000 and 55,000 lb. per sq. in. have been extended to $L/b = 40$, as shown by the dotted lines. At this point, the values for P/A derived from the respective secant formulae are 10,260, 10,670 and 11,010.

Deflection

Structures fabricated with high-tensile steels may show greater deflection than those designed with ordinary carbon steel of structural grade. This condition arises from the fact that the modulus of elasticity, E, is practically constant for all grades of steel. There are some cases in which deflection is of vital importance and must be kept within specified limits, thus precluding the possibility of any weight reduction in the members. On the other hand, there are many instances when advantage can well be taken of the weight reduction effected by high-tensile steels, even though the deflection may be increased.

The deflection of a simply supported beam under a uniform load is given by the expression:

$$y = \frac{5WL^3}{384\ EI}\ \dots\dots\dots\dots\dots\dots\dots\dots(24)$$

$W =$ Total load, lb.
$L =$ Span, in.
$y =$ Deflection, in.
$E =$ Modulus of elasticity, lb. per sq. in.
$I =$ Moment of intertia, in.

Let I_1 and I_2 be the moments of inertia and y_1 and y_2 the deflections of beams designed for fibre stresses in bending of f_1 and f_2, respectively.

$$y_1 = \frac{5WL^3}{384EI_1}$$
$$y_2 = \frac{5WL^3}{384\ EI_2}$$

Then

$$\frac{y_2}{y_1} = \frac{I_1}{I_2}\ \dots\dots\dots\dots\dots\dots\dots\dots\dots(25)$$

With beams of equal depth, $S_1/S_2 = I_1/I_2$ and it was shown in Equation (6) that $S_1/S_2 = f_2/f_1$, hence $y_2/y_1 = f_2/f_1$, or

$$y_2 = \frac{f_2}{f_1}y_1\ \dots\dots\dots\dots\dots\dots\dots\dots\dots(26)$$

Equation (26) applies to other types of loading on the same span since the deflection formulae are of the form, $y = \dfrac{\text{Constant}}{I}$. In Table XII are given a few values of the ratio, f_2/f_1.

By a simple transformation, the deflection formula of Equation (24) may be expressed in the following terms:

$$y = \frac{5fL^2}{24Ed}\ \dots\dots\dots\dots\dots\dots\dots\dots(27)$$

$f =$ Unit stress in bending, lb. per sq. in.
$d =$ Depth of beam or girder, in.

Equations (24) and (27) show that decreases in deflection can be brought about by any of the methods listed below:

1—Decrease the load W (equivalent to reducing the moment).

2—Decrease the span L.

3—Increase the depth d.

An additional method is that of introducing restraining moments at the ends of the span, such as those over the supports of a continuous beam.

It may seldom be necessary to resort to any of these changes but they are the available avenues of reducing deflection when required.

Table XII—Values of $\dfrac{f_2}{f_1}$

| f_1	f_2	$\dfrac{f_2}{f_1}$
16,000	24,000	1.50
16,000	27,000	1.69
16,000	30,000	1.88
18,000	24,000	1.33
18,000	27,000	1.50
18,000	30,000	1.67

Pressed Shapes

The reductions in thickness of material made possible by the high-tensile steels often bring the required sections below the minimum thicknesses of standard rolled shapes. In such cases there is often an advantage to be gained by pressing and forming shapes from strip, sheets or plates. The designer has a wide latitude and may "tailor-make" the pressed shapes to fit his particular construction. No handbook of properties for such sections is available and individual calculations have to be made for each one.

All pressed sections have fillets or rounded corners wherever there is an angular change in the direction of the surface. The determination of the properties of a section may be simplified by the use of the properties of fillets shown in Table XIII. The first group of formulae apply to the general case and will be found useful for irregular sections. The right-angle fillets of the second group are of much more frequent occurrence and the properties have been tabulated for three different values of the inside radius of curvature. Tables similar to those of Tables XIII(a) and XIII(b) can be prepared easily for various thicknesses and radii of fillets, thus making a tabulation of more immediate value. The moments of inertia of rectangles about axes other than the principal axes, are sometimes required and the formulae for such cases are given at the right Table XIII.

Table XIII—Properties of Fillets

θ and B are in radians

Radian $= 180/\pi$
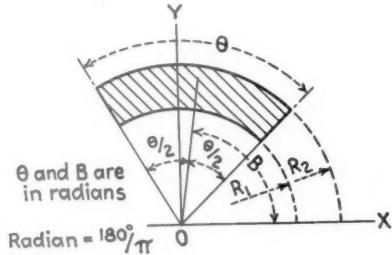
$$\text{Area} = \theta/2 \; (R_2^2 - R_1^2)$$

$$M_x = \frac{R_2^3 - R_1^3}{3} \left(2 \sin \frac{\theta}{2} \; \sin B\right)$$

$$I_x = \frac{R_2^4 - R_1^4}{8} \left(\theta - \cos 2B \sin \theta\right)$$

Attention should be paid to the signs of the sines and cosines.
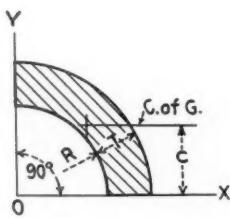
Property	$R = T$	$R = 2T$	$R = 3T$
Area, sq. in.	$\dfrac{3\pi T^2}{4}$	$\dfrac{5\pi T^2}{4}$	$\dfrac{7\pi T^2}{4}$
M_x	$\dfrac{7T^3}{3}$	$\dfrac{19T^3}{3}$	$\dfrac{37T^3}{3}$
I_x	$\dfrac{15\pi T^4}{16}$	$\dfrac{65\pi T^4}{16}$	$\dfrac{175\pi T^4}{16}$
$c = \dfrac{M_x}{A}$	$\dfrac{28T}{9\pi}$	$\dfrac{76T}{15\pi}$	$\dfrac{148T}{21\pi}$
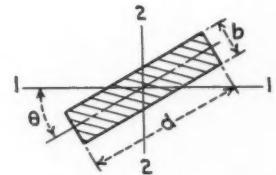
$$I_{1-1} = \frac{bd^3 \sin^2 \theta}{12} + \frac{b^3 d \cos^2 \theta}{12}$$

$$I_{2-2} = \frac{bd^3 \cos^2 \theta}{12} + \frac{b^3 d \sin^2 \theta}{12}$$

Table XIII(a)—Numerical Values of Properties of Fillets, R = 2T
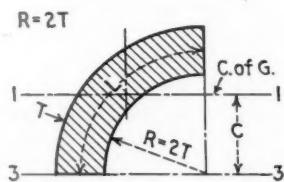
T, in.	L, in.	Area, sq. in.	C, in.	M_{3-3}	I_{3-3}	I_{1-1}
1/16	.2454	.0153	.1008	.00155	.000195	.0000389
3/32	.3682	.0345	.1512	.00522	.000986	.0001969
1/8	.4909	.0614	.2016	.01237	.003116	.0006222
5/32	.6136	.0959	.2520	.02416	.007607	.001519
3/16	.7363	.1381	.3023	.04175	.015774	.003150
7/32	.8590	.1879	.3527	.06629	.029224	.005836
1/4	.9817	.2454	.4031	.09896	.049854	.009955
9/32	1.1045	.3106	.4535	.1409	.079857	.01595
5/16	1.2272	.3835	.5039	.1933	.12172	.02431
11/32	1.3499	.4640	.5543	.2573	.17820	.03559
3/8	1.4726	.5522	.6047	.3340	.25239	.05040
13/32	1.5953	.6481	.6551	.4246	.34763	.06942
7/16	1.7181	.7517	.7055	.5304	.46758	.09337
15/32	1.8408	.8629	.7559	.6523	.61618	.12304
1/2	1.9635	.9817	.8063	.7917	.79767	.15929
17/32	2.0862	1.1083	.8566	.9496	1.0166	.2030
9/16	2.2089	1.2425	.9070	1.1272	1.2777	.2551
19/32	2.3317	1.3844	.9574	1.3257	1.5862	.3167
5/8	2.4544	1.5340	1.0078	1.5462	1.9474	.3889

Table XIII(b)—Numerical Values of Properties of Fillets, R = 3T
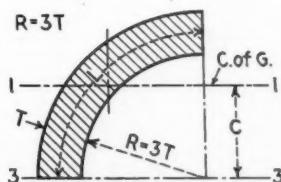
T, in.	L, in.	Area, sq. in.	C, in.	M_{3-3}	I_{3-3}	I_{1-1}
1/16	.3436	.0215	.1402	.0030	.000524	.000102
3/32	.5154	.0483	.2103	.0102	.002654	.000517
1/8	.6872	.0859	.2804	.0241	.008389	.001634
5/32	.8590	.1342	.3505	.0471	.020481	.003990
3/16	1.0308	.1933	.4206	.0813	.042469	.008273
7/32	1.2026	.2631	.4907	.1291	.078679	.015327
1/4	1.3744	.3436	.5608	.1927	.134223	.026146
9/32	1.5463	.4349	.6309	.2744	.21500	.04188
5/16	1.7181	.5369	.7010	.3764	.32769	.06383
11/32	1.8899	.6496	.7711	.5010	.47978	.09346
3/8	2.0617	.7731	.8412	.6504	.67951	.13237
13/32	2.2335	.9073	.9114	.8269	.93593	.18232
7/16	2.4053	1.0523	.9815	1.0328	1.25887	.24522
15/32	2.5771	1.2080	1.0516	1.2703	1.65895	.32316
1/2	2.7489	1.3744	1.1217	1.5417	2.14757	.41834
17/32	2.9207	1.5516	1.1918	1.8492	2.7369	.5331
9/16	3.0925	1.7395	1.2619	2.1951	3.4400	.6701
19/32	3.2643	1.9382	1.3320	2.5816	4.2705	.8319
5/8	3.4361	2.1476	1.4021	3.0111	5.2431	1.0213

Cost Comparisons

No study of light-weight construction would be complete without a comparison of costs with those prevailing for designs using ordinary structural carbon steel. In some instances the cost may be increased by the high-tensile steels but compensating advantages will be found in the items of operating and maintenance costs and often in increased revenue which may result from the increased pay-load capacity. The nomographic chart in Fig. 9 provides a ready means of making rapid studies of the relation between weights to give equal costs of material for two differently priced steels.

For the purposes of illustration, assume a structure to be fabricated with a grade of steel costing 1.90 cents per pound and that the total weight is W_1 pounds. Let it be required to find the weight of steel in a new design in which a high-tensile steel costing 2.80 cents per pound, is to be used. In this example $P_1 = 1.90$ and $P_2 = 2.80$ and by laying a straight edge across the diagram connecting these respective values, we read on the middle vertical scale the value of $P_1/P_2 = 0.68$. Therefore the weight of the structure with high-tensile steel should not exceed 68 per cent of the original weight, W_1, in order that the total cost of material shall not be greater than that with the cheaper steel.

With this ratio of weights it becomes possible to determine in a preliminary way the physical requirements of the high-tensile steel to meet these conditions. Assume the first structure, with the 1.90-cent steel, to have been designed with a working unit stress in tension of 16,000 lb. per sq. in. Referring to the chart in Fig. 1, lay a straight edge across the diagram connecting $f_1 = 18,000$ and $f_1/f_2 = P_1/P_2 = 0.68$ and where it crosses the right-hand vertical scale read 23,500 for f_2. This is the necessary working unit stress for the high-tensile steel and from Table II it will be seen that this corresponds to a steel having a yield-point strength of about 45,000 lb. per sq. in.

There are other problems which will be encountered in the study of the application of high-tensile steels but it is hoped that the discussion in this paper will prove of definite assistance to those who are concerned with such investigations.
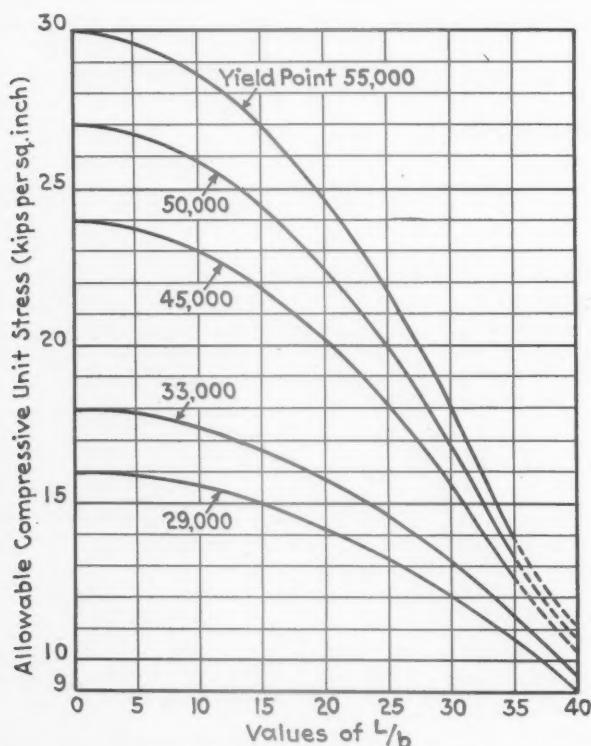
Fig. 8—Allowable compressive stresses for laterally unsupported compression flanges

P_1 = Price (cts. per lb.) of steel in basic design
P_2 = Price (cts. per lb.) of steel in new design
W_1 = Weight of steel in basic design
W_2 = Weight of steel in new design
For equal costs, $P_1 W_1 = P_2 W_2$
$$W_2 = (P_1/P_2) W_1$$
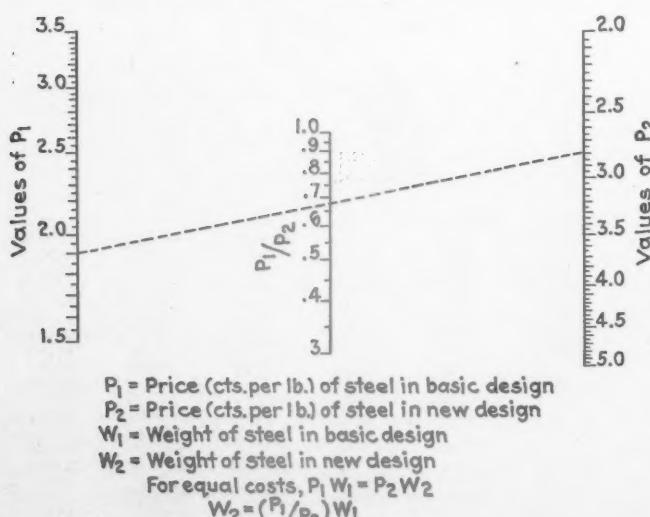
Fig. 9—Ratio of weights for equal total costs

New High-Tensile Steel

To meet an increasing demand for a special high-tensile steel, Armco HT-50 has been developed by the American Rolling Mill Company, Middletown, Ohio.

Tests on specimens show the impact tensile strength is 5,000 lb. per sq. in., nearly double that of mild steel, but care has been taken to avoid strength in excess of actual requirements. This permits the use of advanced methods of fabrication and welding. Armco HT-50 has a sufficiently high yield point to be used on jobs with the highest practical stresses, but still maintains sufficient ductility to be adaptable for varied fabrication.

While the endurance limit of Armco HT-50 is 48,000 lb. per sq. in., the yield point is 47,000 lb. per sq. in. in the hot rolled grades. Few materials offer an endurance limit equal to or greater than the yield point. Tensile strength is 67,000 lb. per sq. in. in the hot rolled grades and 70,000 lb. in cold rolled. Elongation in two inches is 28 per cent in hot rolled sheets.

Because welding is now an accepted method in the assembly of structures that will be moved continually at high or low speeds, the carbon is confined to a very low percentage, strength being obtained by other additions. Finished welds closely approach the unwelded parts in physical properties. Sheets and plates can be welded with many varieties of the so-called shielded arc electrodes.

Atmospheric corrosion resistance of Armco HT-50 is said to be four to six times that of ordinary steel. Sheets and plates are offered in 20-gage and heavier, in all finishes and sizes ordinarily supplied in mild steel, hot and cold rolled grades.

ANOTHER RECORD.—To the French railways goes a record of which they can hardly be proud. In a recent boiler explosion on the locomotive of a passenger train at Tenay-Hautville, the running gear was left on the track, while the rest of the engine was blown into a cornfield exactly 1,738 ft. away. This must be a long distance record for boiler explosions.

Failures of

Locomotive Parts*

By F. H. Williams†

FAILURES of side rods in service, or the scrapping of such rods because of cracks discovered by vigilant inspectors, are sometimes occasioned by holes in ends of the rods that, for one reason or another, are not now required and which are usually plugged. A typical hole of this sort is shown in the drawing. The stop plugs were formerly placed at the bottom of the rod, but the projecting plug prevented the rods from being stood on their edges in the shop, and the plug was transferred to the top in connection with the oil or grease cup. In general the failures are caused by cracks which start from:

1—A hole which has been drilled and tapped, but is not now required, and is left open.

2—A hole filled with a steel plug, which is held in place by welding.

3—A hole filled with a plug, which is trimmed off and is held in place by being peened over with a hammer.

Here, as in the type of failures which was described in the article in the *Railway Mechanical Engineer* of May, 1936, page 190, fatigue cracks are started from what may appear to be insignificant details. The metal may be slightly torn by the finishing tool in machining, or the sharp edges of the hole may not be properly rounded. The condition is, of course, aggravated in the case of side rods, which are subjected to severe alternating stresses.

"Do you want a microscopic finish?" I have been asked. We do want the finest finish that can reasonably be obtained. If we find that a number of failures result from what we consider a standard finish, then it is evident that steps must be taken to insure a higher and better standard. Something is surely wrong when it is found that fatigue cracks almost universally start from places which are clearly indicated by the tool marks to be rough finished.

The illustrations which accompany this article emphasize the point that I am trying to make. Fig. 1 illustrates the side view of a section at the end of the side rod, which was removed because of a crack discovered by an inspector. This photograph does not show the crack, which started on the inside near the center of the segment. The punch marks to the right of the letter *E* are markings which have no relationship at all to the failure. The photograph is used merely to give an idea of the shape and size of the section of the rod where the crack started. The exact location of this section is shown on the drawing between the X-X lines.

The crack on the inside of the eye of the rod is not very clearly defined but appears as a white streak about midway between the parallel chalk marks designated by the arrows in Fig. 2. Here the crack was apparently caused by a combination of a sharp edge in the plugged hole and rough finish of a diamond pointed boring tool. One indication of this is that the crack is a little to the left of the center of the plugged hole, where the thickness of the section is slightly greater than through the center. There may be some question as to the rough finish starting this crack, because it is at right angles to the tool marks. A microscopic examination, however, would indicate that the metal was torn at the edge of the hole in which the plug was fitted, thus causing a

slight defect from which the fatigue crack started. In this particular case the original plug was loosened; it was removed and the hole was filled by the electric welding process. It was then retapped for the plug, although this is indicated only slightly in the photograph by the traces of an inner circle.

Failures are on record, due to breakages from fatigue cracks caused by rough machining, which have caused great monetary losses. That jobs of this sort should get by occasionally is excusable, but to consider this sort of finish as standard practice—and this seems to be the case in many places because of the frequent failures which occur—is a thing to be deplored and should be rectified. Frequently failures are classed as "failed from flaw in material," when it was quite likely that they were caused by poor machine work.

Fig. 3 shows an example of a crack in a side rod starting from a hole which had been filled with a plug which was fastened in by an electric welding operation. The same tool marks appear, but much fainter than in Fig. 2; this is apparently due to the wear on the rod. Cracks will be noted on either side of the plug, one of them almost on the center line of the plug, but the other one quite off center. The two parallel bands are markings of white paint to designate the cracks.

The crack in the rod in Fig. 3 was opened up under the hydraulic press, as shown in Fig. 4. Apparently the metal deposited by the welding was not properly fused around the edges of the hole and the contacted edges were hardened and made brittle by the heat of welding.
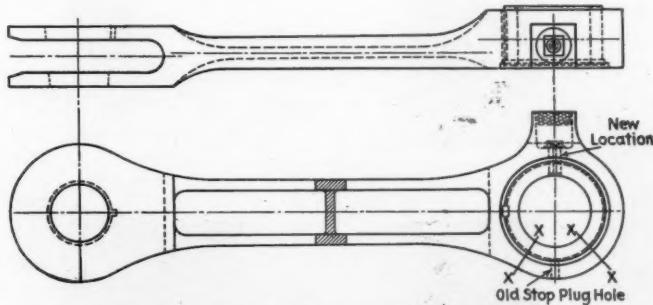
Side rod showing location of old stop plug hole

The fractured parts of the rod after it was opened up by the hydraulic press are shown in Fig. 5. It will be noted that the crack on one side of the plug had not progressed to nearly the same extent as the one on the other side. Quite probably the primary crack was started on the side where the break had progressed more extensively. While the photograph does not show it clearly, a close examination of the crack indicated that it was of the fatigue variety.

Another example of a similar crack, which was discovered in time to prevent a failure in service, is shown in Fig. 6.

A typical fractured side rod through a plugged hole is shown in Fig. 7, where the fatigue cracks extend

FIG. I
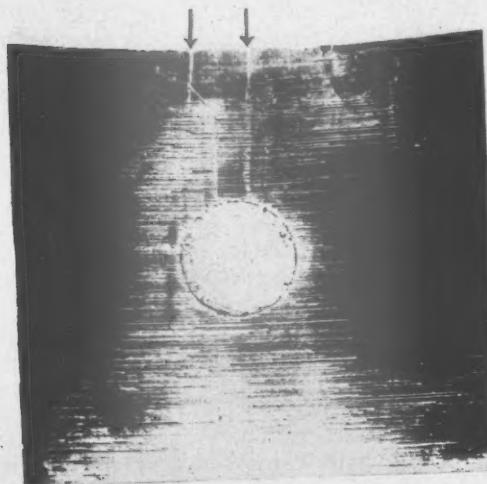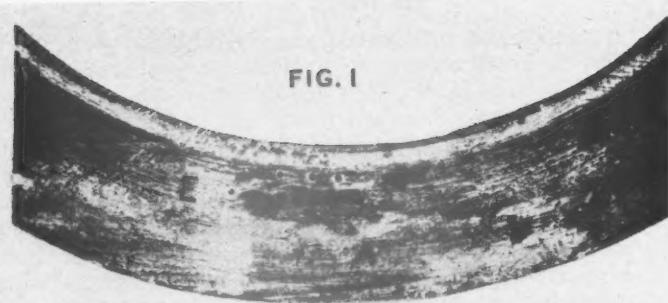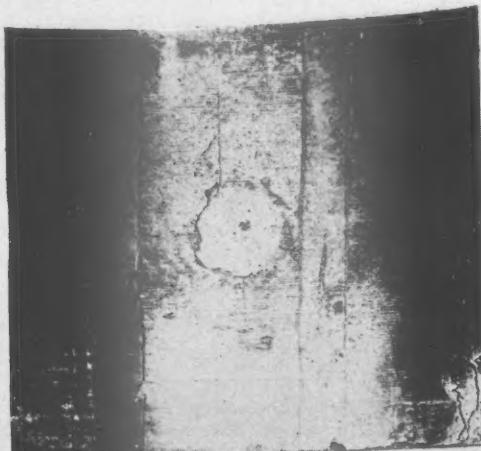
FIG. 2

FIG. 3
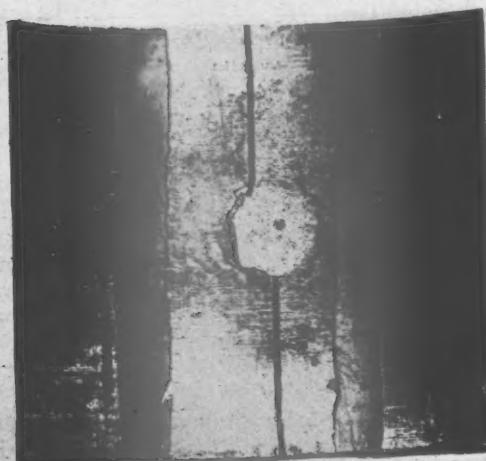
FIG. 4
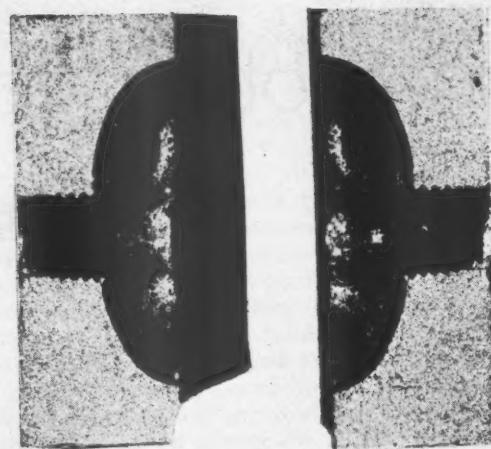
FIG. 5
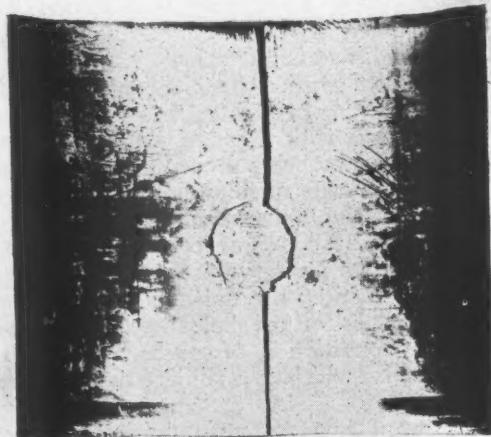
FIG. 6
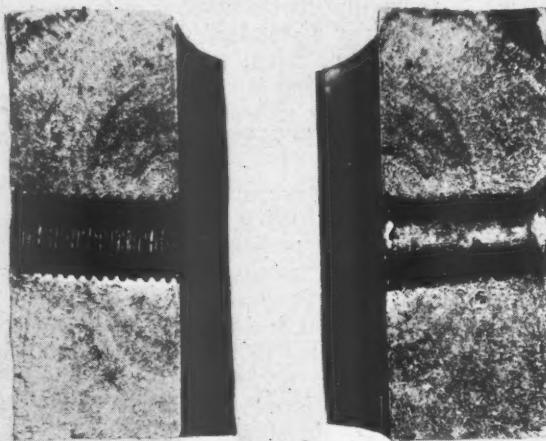
FIG. 7
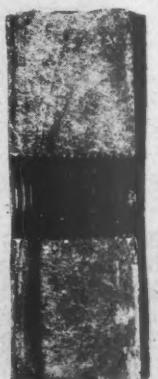
FIG. 8

Figs. 1 and 2 (left)—Section of side rod, cracked through the eye (see portion between X—X lines on drawing). Fig. 1 is reproduced simply to give some idea of the thickness of the section of the rod where it was cracked. Fig. 2 is a view of the inside of the eye, showing the marks of the cutting tool; the crack is at right angles to these marks, midway between the two chalk marks designated by the arrows. Fig. 3— View inside the eye of another cracked side rod. Fig. 4—Shows what happened when the crack in Fig. 3 was opened up by an hydraulic press. Fig. 5—Fractured parts of side rod shown in Figs. 3 and 4. The fatigue crack had extended to a considerable extent before it was discovered. Fig. 6—Another view of the inside of an eye of a side rod, with a crack which started from a stop plug hole. Fig. 7—A break caused by a fatigue crack originating at a stop plug hole and at the inside of the eye of the side rod. Fig. 8—Another typical fracture of the end of a side rod, starting from a stop plug hole; this section was somewhat thinner than the rods shown in the other illustrations.

for rounding the edge. Too much stress, however, cannot be placed upon the necessity of a smooth finish on all machining operations.

Fig. 9 is an excellent example of a rough finish, which is a splendid breeding place for fatigue cracks, particularly under the reverse stresses to which the side rods are subjected. Tool marks in this case are thin, about 72 per inch, and the illustration is an enlargement of about six diameters. We must face the facts and must clearly understand that even the smallest details must not be ignored in studying to find the causes of breakages.

It is indeed fortunate that most of the actual failures of side rods occur at the time the locomotive is starting, so that the damage is less serious than if it were traveling at high speed. Even at that, however, it is a costly process to replace the rods and the locomotives, which must be temporarily taken out of service until repairs can be made.

"Fine feathers make fine birds." Small things must not be ignored. Fine finishes make fine locomotives.

Evans Auto-Duplex All-Steel Car Partition

After almost a year of test service in a Great Northern box car, it is announced that the Evans Auto-Duplex all-steel car partition is now ready for production. Built by the Evans Products Company, Detroit, and distributed by Coordinated Transportation, Inc., St. Paul, Minn., this new car door, or partition, in effect makes a box car a dual purpose car. In other words, it may be used for one-way loading as a privately sealed compartment car and on the return trip as a standard box car for carload freight. The use of the partition is designed to minimize empty car mileage on unbalanced l. c. l. runs and convert many obsolete automobile cars into usable rolling stock.

The partition, which is of steel, is designed to fit cars with opposite or staggered doors. The partition folds on the diagonal, and when not in use is folded into the roof of the box car. When in place, the partition separates one end of the car from the other.

Fig. 9—Enlargement to six diameters of the surface of the bore in the eye of a side rod; about 72 threads per inch. What a menace!

across the entire section. Fig. 8 illustrates another complete fracture of a somewhat thinner section.

As indicated in the previous article in the May, 1936, *Railway Mechanical Engineer*, the fatigue crack is identified by the appearance of the fracture after the break. It progresses slowly at first (it is sometimes known as a progressive crack), the waves or markings in the fracture being close together. These gradually grow larger and rougher, until when the break occurs the fracture is quite coarse. The first waves are less than one hundredth of an inch in width, while the last ones may measure anywhere from one-quarter to an inch or more. Such fractures practically always start from the inside of the eye of the rod and work outward through the section.

The drilling of a hole through the rod leaves the edges sharp, with roughnesses that may result in the starting of fatigue cracks. The remedy is, of course, to round off these sharp edges; some railroads even insist that the surface be polished. A simple machine tool can be used

Evans all-steel car partition as applied in the test car

EDITORIALS

Oelwein Shop Improvements Produce Results

Railroad back shops differ in a number of important particulars from high-production industrial plants in which articles are manufactured at a profit for public consumption. And yet, the same main objective of maximum output per unit of cost, and many of the same general principles of operation, apply in both cases. While primarily devoted to maintenance, an analysis of the work of any major back shop will show literally hundreds of repetitive operations on small parts which are, or could be, standardized and manufactured in quantities on more or less specialized, high-production machinery. Maintenance operations on locomotive and car parts also are repeated time and again and therefore are subject to handling on a production basis.

The extent to which railroad shops can be organized and operated on this basis depends upon at least three important elements: (1) The *vision* of responsible mechanical department and shop officers; (2) their willingness to adopt, insofar as practicable, production methods successfully used in other modern railroad and industrial shops, and (3) the success of local shop supervisors in "selling" their managements to the urgent necessity of installing modern equipment and methods. This must be done if maintenance costs are to be reduced and equipment maintained at the high standard essential for safe and satisfactory operation at the ever-increasing speeds demanded by the modern shipping and traveling public.

Still another factor in the problem, which must not be overlooked, is the provision for as uniform shop operation as possible, considering the variable character of railway traffic and equipment requirements. When the Chicago Great Western, for example, revamped its shop facilities at Oelwein, Iowa, to the extent of purchasing all new machinery in place of equipment averaging over 30 years old, as described in the June, 1935, *Railway Mechanical Engineer*, its officers did not let the matter rest there and say, "We have installed new machinery at a cost of approximately $100,000. Now we can cut our costs." They took the necessary steps to provide the uniform operation without which potential savings in unit shop costs can never be realized.

Previous to 1934, the method of shop operation at Oelwein was more or less spasmodic. Program work was sometimes completed as contemplated, but frequently dropped for a period of two or three weeks when carloadings fell off. When the shop re-opened a loss in output of as much as three days' work usually resulted due to delays in locating misplaced tools,

hunting for material robbed from the shop for use on light repair equipment, and getting the shop organization really to function again. To prevent a recurrence of these costly delays, the purchase of new machinery and equipment at Oelwein shops was coupled with a reorganization of the entire method of shop procedure. Budgets are now prepared 30 days in advance for maintenance work on locomotives and other equipment which have been given a thorough inspection, and necessary repair materials ordered so that they will be on hand before the equipment is shopped. Each locomotive is scheduled from week to week and every foreman furnished with a copy of the schedule. The stores department also receives a copy and is required to see that all necessary material is available at the shop prior to the scheduled date.

This co-ordination of modern facilities and shop practice has resulted not only in lower costs but has provided a more consistent output with steady employment for the employees. It has also permitted the railroad to do additional maintenance work on equipment with the savings which have resulted from the installation of new machinery. Since July 9, 1934, the shop has worked steadily without layoff periods, except during the seasonal holidays. Other important savings, somewhat difficult to evaluate, result from more accurate work and closer tolerances possible with modern machines, increased service life with surface-hardened materials finished on grinders, and generally improved morale of shop men working with modern tools. It is estimated that the Chicago Great Western has already saved in the last two years its entire investment in improved machines and shop equipment.

This saving, as a result of replacing obsolete equipment, would not have been so great had the equipment been only 10 years or so old and still fairly modern, but, as a matter of fact, the machines were over 30 years old on the average. The resultant low production of relatively inaccurate work can be more readily imagined than described. It took from 15 to 40 minutes to turn a motion-work pin on a 30-year old turret lathe, whereas this operation can be performed in a few minutes on a modern lathe. Many other operations were being performed on similarly inefficient worn-out machine tools. Drills, reamers, milling cutters, taps, dies, etc., would not "stand up" when cutting modern steels, and rapidly wore out or broke. Obsolete pneumatic tools also were wasteful of air, not to mention shopmen's time, and seriously retarded production. A comparison of the time required to perform several typical locomotive shop operations with the old equipment and with new modern facilities is shown in the table.

An indication of the improved quality of work per-

formed at Oelwein shops since the installation of new machinery is afforded by the substantial increase in the number of locomotive miles run per engine failure, this mileage being 53,256 in 1932; 68,873 in 1933; 78,455 in 1934; and 121,208 in 1935. Not all of the credit

Comparison of the Time Required for Several Typical Operations with New Versus Old Shop Equipment

	Old	New
Unwheeling a 2-8-2 Class locomotive....	10.5 man-hours	1.7 man-hours
Wheeling a 2-8-2 Class locomotive......	26.7 man-hours	5.4 man-hours
Turning one pair of 56-in. driving tires.	3.0 man-hours	.9 man-hours
Pressing wheel centers off and on.....	.5 man-hours	.17 man-hours
Grinding valve links.................	7.0 man-hours	.75 man-hours
Removing flexible caps, 2-10-4 locomotives	42.0 man-hours	5.0 man-hours
Applying flexible caps, 2-10-4 locomotives	52.0 man-hours	6.5 man-hours

for this improvement can, of course, be given to new machinery, since numerous other factors have an important bearing on failures and maintenance costs.

Some railroads have been prone to defer the modernization of their shop facilities due to the heavy charges to operating expenses which are involved, irrespective of the amount of savings that the new equipment will bring. If the purchase of new equipment will result in a saving of 20 per cent or more on the investment, some roads feel that the installation is justified. In a great many instances of individual machine tools, however, savings substantially greater than 20 per cent may be anticipated. The new equipment purchased would not necessarily have to mean an immediate cash outlay, as arrangements could be made with machinery manufacturers for payments spread over a reasonable period of time.

Apprentices— An Imperative Need

Improved business conditions during recent months, even though production is well below what might be considered normal, has focused attention on one of the weak spots in our present-day set-up. Recruiting and training of employees has been at an exceedingly low ebb in recent years; indeed, it has been practically discontinued in many industries. Meanwhile many of the older men have died or have retired; others, in the prime of life, have been laid off and have related themselves to other occupations. Many of this latter class will never resume their former occupations. American industry, therefore, is facing a serious situation, if and when business swings back into a more normal stride.

Apprentice Training News, a bulletin issued by the Federal Committee on Apprentice Training at Washington, in commenting upon the revival of apprentice training on the railroads, makes this suggestion: "The idea of restoring training, with the related instruction, under public school supervision has met with general approval. Several roads have decided to put on apprentices immediately. In Colorado an agreement has been made whereby the railroads and vocational schools will co-operate in providing a traveling instructor."

The railroads during the first quarter of the present century took the leadership in introducing modern apprentice training methods. This included the introduction of apprentice shop instructors, as well as classroom instruction. Naturally, also, as higher standards were introduced, more and more attention was given to the proper selection of the apprentices. Largely because of these methods—on those railroads which were progressive enough to adopt them—a goodly supply of capable mechanics was provided, some of the more outstanding of these well-trained journeymen eventually qualifying for positions as foremen and supervisors.

The shutting off of the influx of young mechanics into our railroad shops in recent years promises to have serious effects, unless determined measures are taken immediately to resume recruiting, at the same time making unusual efforts to see that the very best sort of instruction is given to the apprentices.

Are You Living Off Your Family?

Some years ago at a railroad meeting, which was attended by men from several departments, a rather heated discussion developed which gradually resolved itself into a game of "buck-passing," representatives of one department inferring, at least, that certain conditions might be corrected if the representatives of another department would do what they should. There was present a railroad man with years of experience who, tiring of much pointless argument, got up and eased the tension somewhat by prefacing his remarks with the statement that it was quite obvious that many of those in attendance at that meeting were "members of the same family but apparently not closely related." The readers of this publication have been entertained and we venture to say constructively educated during the past months by the writings of Walt Wyre, and one gains the impression upon reading this month's contribution entitled "Robbing Peter," which appears on page 264 that the mechanical and maintenance departments may be members of the same family but not very closely related. The ultimate solution to Foreman Evans' perplexing problem was one which, unfortunately, is too often the only one available to hard-pressed foremen.

The broad problem of maintenance of equipment is one which involves properly designed equipment, adequate repair facilities and intelligent management. Walt Wyre has portrayed in his inimitable manner another of Jim Evan's dilemmas out of which he usually finds a way. In this particular one, we venture to suggest that management is somewhat at fault for Master Mechanic Carter turned his back on a situation about which something should be done. It is to be hoped that no mechanical department man in a position of responsibility will read this month's story by

Walt Wyre without realizing that every time a situation arises wherein the efficient service of a railroad is handicapped by the existence of obsolete facilities somebody pays the bill. A railroad may have fine tracks, modern locomotives and cars, a willing and efficient personnel but if its shop and enginehouse facilities are not able to meet the standards of performance which modern equipment is able to give, the profits that are realized by the modern facilities in one department may be to a large extent offset by the losses in another. Under the conditions with which railroads have had to contend for the past few years, there has grown up a tendency to look out for oneself and too often that pride of departmental accomplishment in keeping within the budget has been carried out at someone else's expense.

There are so many evidences of the value of modern machine tools and shop equipment that it is not so much a problem of determining whether a road can afford new facilities as it is one of determining how long it can afford to continue to pay the losses of inadequate facilities. When one considers that the average railroad does not expect shop facilities to pay for themselves in less than five to ten years and that most modern units if used to capacity will pay for themselves in considerably less than that, it will be surprising if the hesitancy in modernizing repair facilities that has existed for the past several years is much longer continued. .

Firemen on Diesel Motive Power

Announcement was made near the end of May that the New England roads have settled the issue which had threatened to result in a strike of the members of the Brotherhood of Locomotive Firemen & Enginemen by agreeing to use firemen as helpers in the cabs of present Diesel locomotives and motor cars. This agreement follows an aggressive campaign which was waged by the Brotherhood on the ground of safety, which is also the ground on which efforts have been made to secure legislation requiring two men in the cabs of Diesel-driven rolling stock in some of the other states.

One can understand the desire of the Brotherhood officers to secure as many jobs as possible for its members and at the same time to endeavor to check a trend caused by any increase in the general utilization of Diesel motive power which otherwise would materially curtail the opportunities for employment of the men which this Brotherhood represents. As a safety measure, however, the requirement that enginemen in the cabs of Diesel-driven cars and locomotives be accompanied by helpers is of extremely doubtful value. There are many instances of the ineffectiveness of the fireman in the cab of the steam locomotive as a check on the engineman in cases of

mental lapse or collapse. Furthermore, where these men are employed on electric locomotives with no duties of their own to occupy their attention, the evidence indicates that they are no more dependable as checks upon the condition and responsibility of the engineman than are the firemen occupied with their own duties on steam power. Indeed, the evidence strongly suggests that the lack of distinctive duties of their own makes them undependable as watchers over the enginemen.

On the Spokane, Portland and Seattle on December 17 of last year occurred a freight wreck within yard limits under conditions which strongly indicate a mental lapse on the part of the engineman which was discovered too late by the fireman and head brakeman, both of whom were in the cab, to permit any effective action to prevent the accident. On January 30 a Reading passenger train was wrecked due to excessive speed on a sharp curve. The evidence strongly suggests the collapse, or the mental lapse, of the engineman a short time before the curve was reached. Emergency application of the brakes, which the position of the engineer's brake valve after the accident would indicate had been made, was too late to be effective. On last September 27 a rear-end freight collision occurred on the New York, New Haven & Hartford in electrified territory. Just before the collision the helper walked back from the front-end of the locomotive to overcome drowsiness and was not present to be of any service in preventing the failure of the engineman properly to observe and obey a restrictive signal indication.

There are two types of conditions against which safeguards are needed. They are (1) the collapse, or (2) the mental lapse of the engineman. It seems probable that the "dead man" type of control is the best protection against the former. Just what protection can be developed against the latter, in which the absence of complete physical collapse may prevent the "dead man" feature from functioning, unless it be assurance of proper health and proper rest on the part of the engineman, it is difficult to visualize. Many instances suggest the inadequacy and unreliability of a second man in the cab as a means of preventing accidents in such emergencies. Indeed, the absence of duties to keep him alert and, to some extent, of an adequate sense of responsibility on the part of the second man in the cab of electric or Diesel-electric equipment, whose only reason for being there is to draw his pay, creates a menace by tending unjustifiably to divide the sense of responsibility on the part of the engineman. It is a serious question whether safety would not actually be promoted if these men were paid for their trips but not permitted to set foot inside the cabs.

One can understand the desire of these men for jobs, but it is difficult to believe in the sincerity of the argument that their jobs promote the safety of railway transportation.

Gleanings *from the* Editor's Mail

The mails bring many interesting and pertinent comments to the Editor's desk during the course of a month. Here are a few that have strayed in during recent weeks.

Is Walt Wyre Color Blind?

You might ask Mr. Wyre if he is certain that Interstate Commerce Commission Form 5's are blue. The ones I have seen were rather pink. I will admit, though, that the effect produced by such an apparition is decidedly blue, if any color sense at all is present at such a time.

From Far Off China

Although the practices adopted by us are somewhat different from yours, we are always looking forward for improvement and ready to take advice and suggestions. It was last year when we were confronted with the problems of broken axles and hot boxes. In the second case, we found references in your January, 1934, issue. You had the same trouble and you also tried to remedy it by adopting one grade of journal lubricant after a series of service tests.

"East of Suez"

Our problems are many in a country like India, where labor is extremely poor and not mechanically minded, and European supervision scarce, whilst the design of rolling stock, particularly for our 5-ft. 6-in. gage presents unusual difficulties, due to the large size of equipment for handling by Indian labor. The articles which are of great use are those dealing with workshop equipment and gadgets. If you could kindly give more particulars of this nature I am sure it will be welcomed by all mechanical railway men out "East of Suez."

New Age in Railroad Transportation

As he widens his knowledge he sees unfolding before his eyes the opening drama of a new age in railroad transportation. In the 30 years I have been in the railroad game, what a transformation has taken place and what have we today? In locomotives: Diesel-electric power, the application of the roller bearing, new type of air brake apparatus, streamlining, new steels, new welding processes, higher boiler pressures. In passenger cars: Air conditioning, the roller bearing, improved dynamo and battery equipments with better lighting, and wonderful improvements in interior appointments.

No Reserve of Trained Mechanics

I do not know of anything of a more serious nature confronting the mechanical departments of the railroads, should they suddenly be offered a large volume of traffic, than the shortage of trained mechanics. When the falling off in traffic occurred five or six years ago and the railroads found it necessary to reduce their shop forces, the younger men were laid off, leaving many of the shops with only a skeleton force of men, all of whom were practically past middle age, as only those who were old in the service had senior standing sufficient to hold a job. Many of these have since dropped out through death and other causes and in many cases their places have not been filled. Due to the length of the depression, the young men who were laid off, when the reduction in forces was first made, have sought employment elsewhere, until now there is no reserve of trained mechanics for building up forces or from which to choose supervisors.

Firing Men

A man recently applied to me for employment. Here is the conversation:

"What is your specialty?"

"I am a maintenance man. I can set up machinery and countershafting and can repair any machine that may need it. I am also fairly good at giving an estimate of how long it will take to get the machine in operation."

"Where did you work last?" I asked.

"I have been working for the ——— Company for four years."

"Why did you leave?"

"Well, to be honest, I was fired."

"What for?"

"I really don't know. They don't tell you over there; you just get an envelope on your way out at noon or night with your pay in it and a note that your services are no longer required; and no one will tell you why."

"Have you no idea at all?" I inquired.

"No, I haven't. I never lost time. I have broken no rules knowingly and have never been bawled out at any time. I did break a small tap on my last job, but I do not think they would fire a man for that. On the other hand, the new foreman over there is just out of college and perhaps doesn't know how easily a tap may be broken, especially when used in awkward locations on repair work. I don't suppose he ever used a tap himself."

"Sorry I have no opening for you," I said. "I am well acquainted with the people over there and am surprised at what you say."

A little later I had the opportunity of meeting the works manager of the plant, with whom I was well acquainted. The following conversation took place.

"Is it true," I asked, "that when you people let an employee out, you don't tell him the reason?"

"Unless it is a reduction in staff," replied the works manager, "they are not given a reason for discharge. We just let them work until the end of the day, and no matter what the cause, it saves a lot of argument and sometimes unpleasant controversy. As they go out, we give them their check and their notice of dismissal in courteous language."

"Well," I said, "don't you think a man is entitled to know just wherein he fell short of requirements?"

"No, I don't think that is necessary at all. If he is so dumb that he doesn't know, then he is too dumb to have around; and if he knows, why is it necessary to tell him?"

"Do you, yourself, always make it a point," I asked, "to know why your men are discharged?"

"Oh, I can find out from the employment clerk if I wish to know. We have over 1,000 working for us and I can't be troubling myself over who gets let out. Do you know why every man gets discharged?"

"Yes, I do," I replied. "I always manage to find time to talk to the man. I like to get his version of it. I like to be sure someone else is not at fault. There are plenty of forms of punishment short of complete dismissal, which need not cost the management nearly as much as a payroll separation would. You know, any citizen could commit quite an offense and it would not cost him $25."

"Well, what do you gain by all your trouble?" asked the shop manager.

"I gain the satisfaction of protecting our company from charges of injustice to its men. Since adopting the practice of investigations, dismissals have practically entirely disappeared and we have the most efficient shop organization in the city, as you yourself have so frequently stated."

With the
Car Foremen and Inspectors

Interior of the reconstructed Port Huron freight car shop while a box-car rebuilding program is being carried on

Port Huron Car Shops

Following a fire which occurred over a year ago and destroyed the north half of the Grand Trunk Western freight car shops at Port Huron, Mich., the shop was rebuilt, enlarged and equipped for the expeditious handling of the heavy freight-car repair and rebuilding programs which it was foreseen would have to be carried out during 1935 and 1936. A total of 240 welded steel hopper cars and 150 steel box cars were rebuilt at Port Huron shops in 1935, and material has been purchased for 350 additional box cars and 600 hopper cars authorized to be rebuilt during 1936. With the improved shop thoroughly organized and employing about 600 men, 40 hours a week, the production is three hopper cars or three box cars a day. This is in addition to light repair work which is carried on outside of the shop, and a considerable volume of work on special equipment cars such as those used for the shipment of automotive gas engines, axle assemblies and other special materials.

The Grand Trunk Western freight-car shop at Port Huron, Mich., consisted of a building 360 ft. long by 160 ft. wide, with brick walls and wooden roof trusses supported on the walls and on posts spaced 20 ft. center to center in each direction. An interior brick wall on the longitudinal center line divided the building into two aisles. The building was floored with concrete, and four tracks extended through each aisle in a longitudinal direction. On January 9, 1935, a fire destroyed all of the north half or aisle of this building, but the brick fire-

wall prevented the fire from getting into the south aisle to which no damage was done, and it was placed back in service in 24 hours, or as soon as service pipes, electric conduits, etc., that passed through the part that was destroyed, could be restored. The fire also destroyed a low wing along a part of the north side of the building that was used for various incidental operations.

The destroyed part of the building was restored by making use of a part of an old station building known as the Whipple car shop at Elsdon yard, Fifty-first street and Central Park avenue, Chicago. Structures at this point included two buildings 80 ft. wide by 500 ft. long, consisting of structural-steel frames with trusses spanning the full 80 ft. and covered on the outside with corrugated metal that subsequently proved to be genuine wrought iron. One of these buildings, equipped with a 7½-ton traveling crane, was dismantled and re-erected at the site of the destroyed half of the building at Port Huron, the additional length being extended beyond the west end of the original building, as shown in the drawing. The building used had a lean-to on one side 160 ft. long by 30 ft. wide. This was also re-erected on the north side of the building at Port Huron, but the span length was reduced to 28 ft. in order to clear an existing track. It was necessary to provide new concrete foundations for the steel columns, but the old floor was retained in service, a cinder floor being provided in the extension to the west as well as in the lean-to on the north. It

256

was necessary to make some alterations in the old steel work for the purpose of introducing reinforcements to take care of corroded portions as well as to remodel the two ends of the building to provide doors that would fit the location of the existing tracks.

The old wrought iron is used in the reconstructed building but in a different manner than before, owing to the desire to provide a type of wall which will be more effectively insulated. For this purpose, a three-ply wall is provided, consisting on the outside of corrugated metal, a layer of ½-in. fiber insulating board, waterproofed, and then the old wrought-iron sheets on the inside. The building is provided with mechanically operated Truscon steel sash, is heated by means of a series of 15-unit heaters using steam at 100 lb. pressure from the shop power plant in copper coil radiators and provided with electric fans. The building is provided with electric-welding circuits, oxygen and acetylene service pipes, outlets for extension lighting cords and for power take-offs, and general lighting is afforded by beehive-type glass reflector fixtures suspended from the roof purlins. Spotlights are used as supplementary sources of light. The lean-to on the north is heated by direct radiation.

The old steel work that was used was taken down by company forces and prepared for used by company forces and also by the Duffin Iron Company of Chicago. The new building was erected and all work done under contract by the Austin Company, Cleveland, Ohio. The 7½-ton traveling crane was reused exactly as in the original installation with the exception that the motors had to be rewired and all of the bearings rebabbitted.

How the Car Rebuilding Operations are Carried On

The 50-ton steel hopper cars, rebuilt at Port Huron shops, were of conventional riveted design, equipped with arch-bar trucks, Type K air brakes. Their light weight was 38,100 lb., nominal capacity, 130,000 lb., cubic capacity, 1,680 cu. ft. and load limit, 130,900 lb. In the rebuilt cars, the use of pressed-steel side panels permitted increasing the cubic capacity to 1,735 cu. ft. with the same inside length, width and height. The extensive use of electric welding, not only in assembling the side panels but in fabricating the entire car, also permitted reducing the light weight to 37,300 lb., or, a decrease of about 800 lb. which is available for additional load-carrying capacity.

Relatively few parts of the car frame and superstructure were salvaged in this rebuilding operation, the good usable material incorporated in the new hopper being valued at only about $300. Aside from the new steel side panels, sheets and structural shapes, other new material applied to the cars includes Type AB brakes and new hand-brake operating mechanisms, cast-steel truck side frames, hopper doors and fastenings and an average of about two pairs of wheels and one new draft gear per car.

The sequence of work in rebuilding these steel hopper cars may be more readily followed by referring to the drawing which shows the new car shop and track layout. Tracks 1 to 4, inclusive, are in the south aisle of the old shop and Tracks 5 to 8, inclusive, in the north aisle, or new shop, the latter being equipped with the 7½-ton
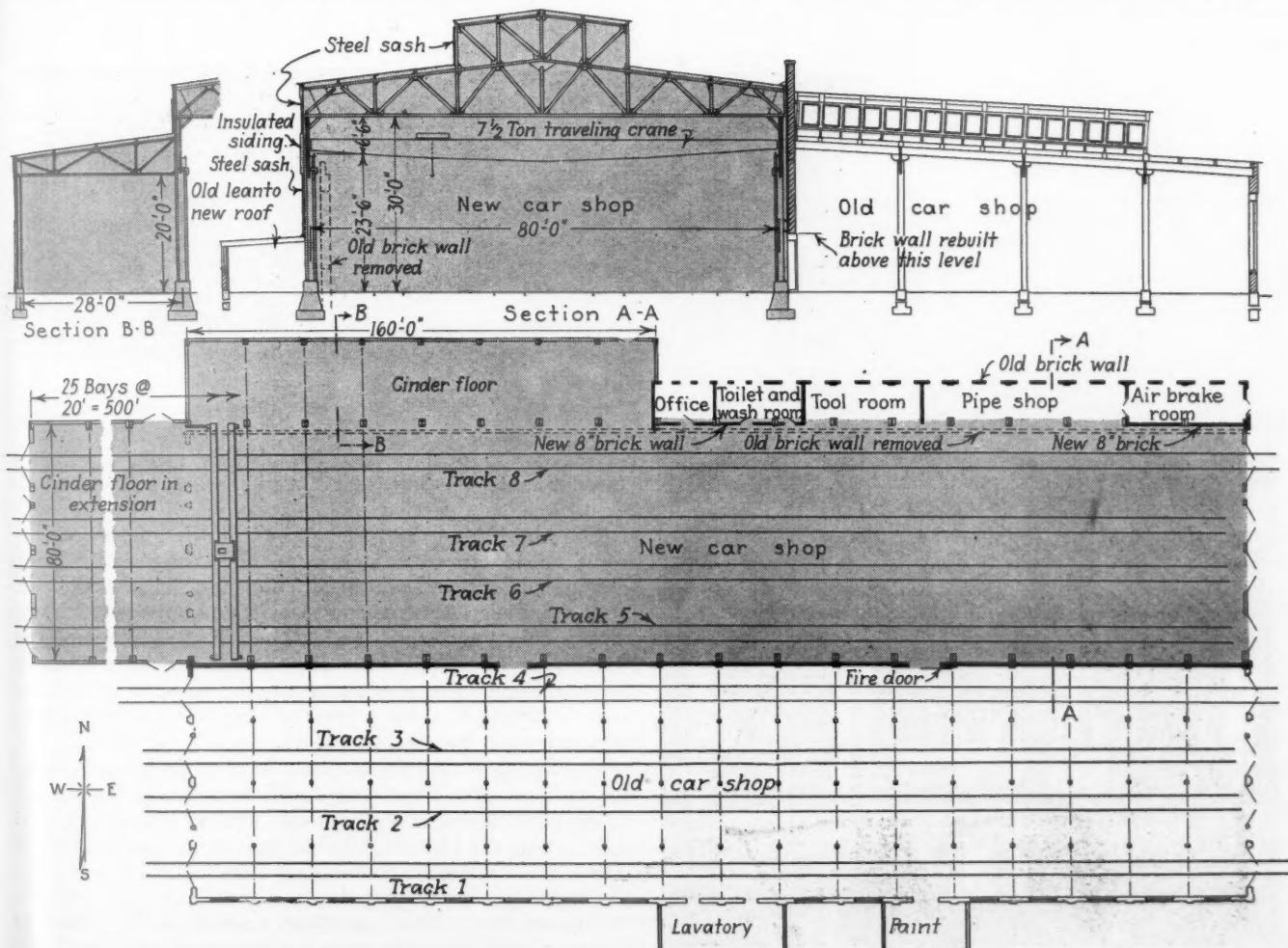
Plan and sections of the Port Huron car shop—Reconstructed portions are indicated by the shaded areas

Welded steel car side comprising eight panels of only five different shapes

Grand Trunk Western 50-ton hopper car before being rebuilt

View of the 50-ton hopper car after reconstruction
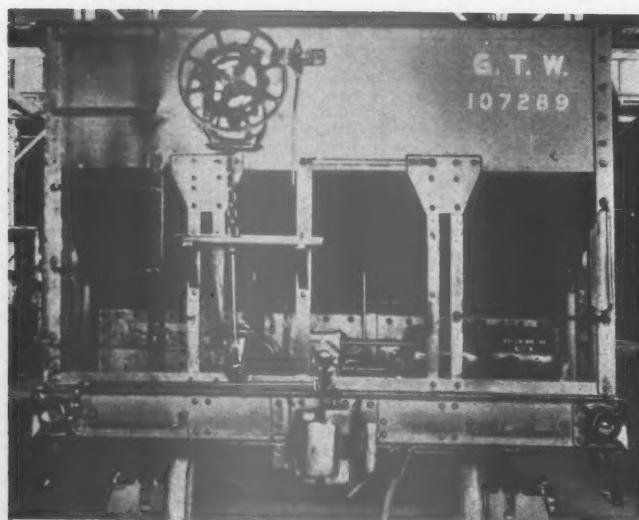
The air brake and hand-brake applications to one of the 50-ton cars

overhead crane. The location of the various shop departments is clearly shown in the drawing. Tracks 4 and 5 are connected by a switch at the east end of the shop so that cars worked through the shop on one of these tracks can be switched to the other and worked back through the shop in the reverse direction. The same method of operation can be used with Tracks 7 and 8 which are also connected by a switch east of the shop building. Car movements within the shop are made almost exclusively by means of an electrically operated car puller.

Steel hopper-car rebuilding work is divided into 10 major operations, as shown in the following schedule:

Operation 1—Old steel cars are cut down, largely by use of the gas cutting torch, on Track 5 about 200 ft. west of the shop, all usable parts, such as wheels, axles, truck bolsters, brake beams, body bolsters, etc., being salvaged. Scrap is loaded here by the locomotive crane for shipment to Battle Creek where major reclamation operations are carried on.

Operation 2—Salvaged parts are moved into the shop on Track 5 on material flat cars, new center sills being assembled at this position.

Operation 3—Advancing to the next position on Track 5, the bolsters, end sills, AB brake equipment, cross hoods, end sheets, longitudinal hoods and inside hopper sheets are welded in place. No-Ox-Id, applied with a brush, is used wherever necessary at metal contact points to prevent corrosion.

Operation 4—At the extreme east position on Track 5 in the new shop, the trucks are assembled, new cast-steel truck slides being applied. These truck assembly operations are facilitated by use of a pneumatic jib crane, the complete trucks being lifted and moved across to Track 6 with the overhead crane.

Operation 5—The assembled underframe is lifted by means of the overhead crane and set on trucks on Track 6 in the east end of the shop. Here the slope sheets,
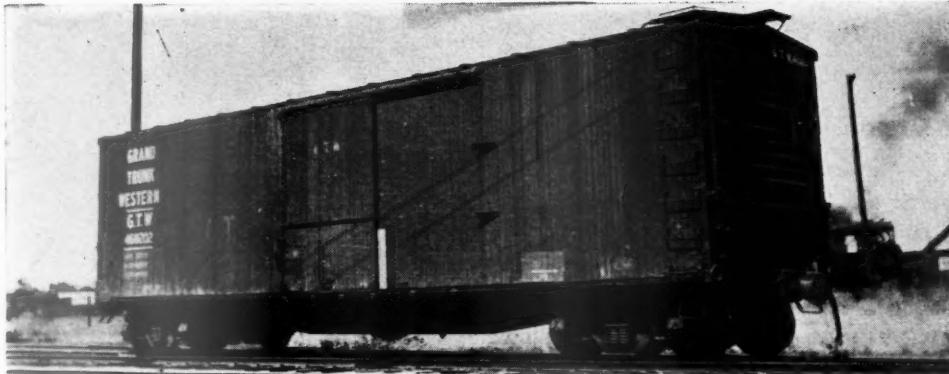
Grand Trunk Western 40-ton box car before being rebuilt

The 40-ton steel box car after reconstruction
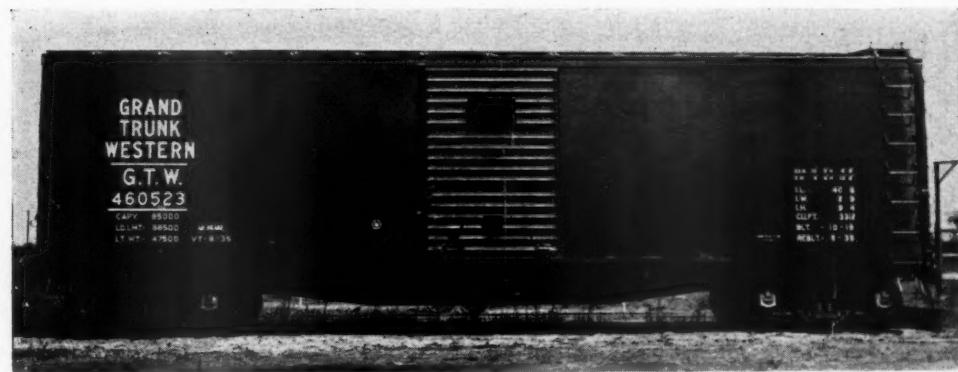
outside hopper sheets and complete welded panel sides are applied by welding.

Operation 6—The car is moved westward on Track 6 and safety appliances fitted in place at the next position.

Operation 7—Floor sheets and side panels are welded together and necessary rivets driven in safety appliances and other parts of the car.

Operation 8—At this position on Track 6, the hopper doors are applied and all pipe fitting work completed.

Operation 9—The cars move out of the shop and are switched to the sand-blast shed (described on page 66 of the February *Railway Mechanical Engineer*) where all sheets are thoroughly cleaned and the priming coat and finishing coat are sprayed on.

Operation 10—The cars are then switched to the north end of the passenger car shop where stenciling is applied by the spray method (see page 67 of the February *Railway Mechanical Engineer*) and a final inspection made, the cars finally being switched to the scales where they are reweighed and released for service.

Side-Panel Welding Details

The pressed-steel panel sides, applied in Operation 5, are previously assembled and welded complete on movable jigs in the machine shop, located just west of the main freight-car shop building. Referring to the illustration with numbered panels, it will be seen that each car side consists of eight separate pressed panels, but only five different sizes and shapes. In other words, the number of different panels has been minimized and each car side consists of a No. 1 and a No. 2 panel, two No. 3 panels, two No. 4 panels and two No. 5 panels.

These eight panels are assembled in the jig, special edge-type clamps being applied to hold the panel edges in alignment. The top side-angle seam is first skip welded at 2-in. intervals, using 1/4-in. coated-wire electrodes. The seams between panels are completely welded and the top-angle seam weld finished. The car side is turned over in the jig and the panel seams welded
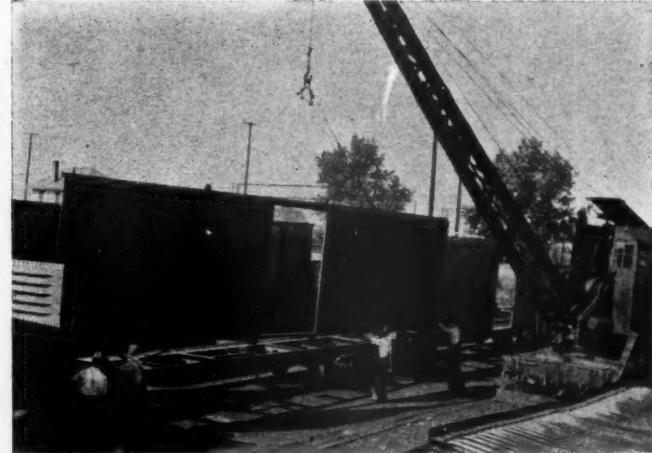
Application of one of the steel car sides by the use of a locomotive crane

downward. The bottom edge of the top angle is then welded to the panels starting from the center and working towards each end to avoid buckling. Any little curvature of the top angle is taken care of in assembly by side-sheet gussets and crosstie beams.

All of this side-panel welding is performed at the rate of 20 ft. an hour or 160 ft. a day. Two welders work simultaneously while each side is being welded. The total amount of welding in fabricating the entire car structure comprises about 995 ft. of welding per car. When the hopper-car rebuilding work is in full swing, welding operations are carried on by two shifts. The shop is equipped with fourteen 300-amp., single-current electric welding machines.

Operations in Rebuilding Box Cars

The 40-ton steel underframe, wood superstructure box cars referred to are rebuilt into modern double steel-

sheathed box cars having a light weight of 47,500 lb., nominal capacity of 85,000 lb. and load limit of 88,500 lb. By the application of steel sides of the Youngstown type, it has been possible to increase the inside car width from 8 ft. 6 in. to 8 ft. 9 in. The car height is also increased from 9 ft. to 9 ft. 4 in. by the application of a filler strip in the two-piece ends. Dry-Lading car roofs and Youngstown steel doors are applied, as are also AB brakes, new hand-brake operating mechanisms and cast steel truck sides. As in the case of the hopper cars, other new equipment includes, on an average, two pairs of wheels and one new draft gear per car.

The only welding in conection with the box cars is a 15-ft. strip in the door-track angle to avoid leaks. All unnecessary holes are plugged, and welding is applied at the corner junctions of the end and side sheets to prevent the possibility of leakage. The shop is fully equipped with modern tools and machinery needed for the expeditious handling of box car work. Floors are

Pneumatic nail-driving machine used in spiking the car floor

spiked with air-nailing machines which drive 3-in to 6-in. spikes. Four pneumatic saws, with 8-in. blades and 2½-in. maximum depth of cut, are used. Nuts are tightened by power nut-tightening devices, while portable cranes handle material directly to the job from the storage pile.

Operations in rebuilding the 40-ton steel box cars are performed in 11 progressive steps, as follows:

Operation 1—The old box cars are dismantled in a track area of about 2,000 ft. west of the shop, where adequate space is available for the removal and burning of all old wood.

Operation 2—Cars are moved to shop Tracks 2 and 3 inside the shop, where they are jacked up on horses and the underframes, steel corrugated ends, trucks, draft gears and AB brake equipment applied.

Operation 3—Each car is then moved just outside of the freight shop building at the west end where fabricated complete steel sides are applied with a locomotive crane.

Operation 4—The car is switched to Track 7 and placed in the shop where corrugated ends are fitted to the sides and steel doors applied in the first position. The entire roof assembly of ridge pole, carlines and purlins is placed in position by use of the overhead crane, these assemblies having been fabricated in advance.

Operation 5—The car advances to the next position on Track 7 where all rivet driving is done and safety appliances put in place.

Operation 6—The car is moved over the cross-over switch at the east end of the shop to Track 8 where wood nailing sills are applied at the first position on the return movement.

Operation 7—The car then advances along Track 8 to the next position where decking is applied and the floors spiked, using the automatic nailing machine, shown in one of the illustrations. Odorless cement is applied with a hand gun around the sides and ends of the cars to seal the decks.

Operation 8—Side nailing posts, wood end fillers, grain slides, door posts, threshold plates and deck transom plates are applied.

Operation 9—At this position the side and end lining are applied.

Operation 10—Complete metal roofs and runboards are applied, No-Ox-Id being used at metal contact points to prevent corrosion. Air brakes are tested.

Operation 11—The car then leaves the shops on Track 8 ready for painting and stenciling which is done outside on tracks south of the shop building. The final inspection is made here, the cars being reweighed and released for service.

Halide Leak Detector For Refrigerant Gases

In a majority of the large number of air conditioning systems now installed in railway passenger cars, Freon is used as the refrigerating agent. This gas is relatively odorless, tasteless, and colorless. Leaks in the system are, therefore, difficult to detect until much valuable gas has been lost or until the system fails to operate. In order to insure effective operation and to eliminate the expense of leakage losses it is necessary that there be provided a quick and sure method of locating gas leaks in these cooling units, either at the time of installation or when in service. With a view to meeting this need, the Oxweld Railroad Service Company, 230 North Michigan avenue, Chicago, has recently perfected and placed on the market the Prest-O-Lite Halide leak detector which consists essentially of a handle with a needle valve and a burner which includes a suction nipple for attaching a rubber hose. A chimney with a copper reaction plate fits on top of the burner. The detector is furnished ready for mounting directly on a Prest-O-Lite MC gas tank. It can also be used with the B or E tank.

The detector flame is adjusted so that the top of the cone is level with or slightly above the chimney. The flame when so adjusted heats the copper reaction plate and the detector is then ready for locating leaks.

The suction tube is used to explore around places

characteristic green or violet color and might not show the exact source of the leak. In this case, the leak can be located by the variation in intensity of the color of the flame. After the source of the leak has been passed, the flame clears almost instantly. This sensitive reaction of the detector saves time in locating leaks, avoids waste of refrigerant gas and costly shutdowns of equipment.

It should be understood that a flame leak detector, such as the one described, should be used only when the refrigerant is a non-combustible gas, and it is, therefore, essential that the nature of the refrigerant gas be known before this device is used.

Testing refrigerant pipe lines for leakage of freon
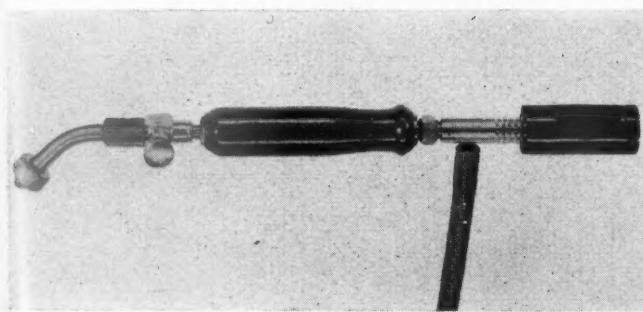
Halide leak detector for locating leaks in non-combustible refrigerant gas lines

where leaks might occur. The rapid flow of acetylene through the burner causes refrigerant gas near the open end of the suction tube to be drawn into the burner where it decomposes into free acids. These acids, coming in contact with the hot copper reaction plate, cause instant color change in the flame. A green tint indicates a small concentration of gas. When a large amount of gas is present, the flame assumes an intense violet color.

If the leak is sufficient to give considerable refrigerant gases to the atmosphere, the flame will burn with the

Fluid Strainer
For Spray Guns

The DeVilbiss Company has developed a new fluid strainer, Type VS, for attachment to the fluid inlet of the Type MBC spray gun. The advantage of having the fluid strainer at the inlet of the gun rather than at the paint-tank outlet lies in the fact that a slight residue of material in the line or other dirt may be carried to the spray gun if the paint is not strained at the last point

De Vilbiss Type VS strainer for Type MCB spray gun

before entering the gun. This may cause defects in the finished surface.

The working part of the strainer consists of a screen reinforced with coiled spring and inclosed in a metal tube. Fluid flow is from the outside to the inside of the screen which is easily removable from the tube for cleaning.

The Type VS strainer is connected by means of its upper or outlet connection to the fluid inlet connection of the spray gun, the fluid hose being connected to the lower or inlet end which is fastened to the lower end of the gun handle to prevent undue strain on the upper connection. The strainer design permits the fluid hose to be attached near the air hose, and to run parallel with it, making the gun easy to handle.

IN THE BACK SHOP
AND ENGINEHOUSE

Fabricating All-Welded
Gas Engine Cylinder Heads

The West Burlington (Iowa) shops of the Chicago, Burlington & Quincy claim the distinction of designing and building the first welded all-steel cylinder head for a gasoline engine. This head was designed for the six-cylinder, 275-hp. Model-120 Winton engine used in most of the Burlington's gas-electric rail cars. The experimental head was completed in January, 1932, and is still in operation. Since that time, 168 of the Model-120 heads have been built as well as 55 heads for the Winton Model-148 engines which are used in some of the larger cars.

The Model-120 head consists of 61 separate parts and is fabricated entirely by electric welding. The majority of parts for this head consists of boiler steel for the flat plates and pressings and mild steel for the various pieces of round-bar stock that are used in the assembly. The time required for assembling and welding is approximately 40 hours a head. The fabricated head has nearly twice the water capacity and has 15 per cent less weight than the cast-iron head which it replaced. Worn valve seats are renewed by electric welding, and as no preheating is necessary, the time required for reconditioning per head is decreased appreciably. Statistics regarding the larger Model-148 head are approximately in the same proportion. A great saving has been realized in the actual cost of the steel head over that of the cast heads.

In addition to the heads, cylinder blocks, upper and lower crank cases and intake manifolds have been constructed, all of steel and in a like manner.

The pre-heating furnace shown in Fig. 1 is an oil furnace using kerosene for fuel, size 31 in. by 53 in. by 28 in. inside, built from angle and sheet, having an oval top and a car bottom. It is lined with firebrick which is also used as the top surface of the car bottom. Track for the car is tee section, and extends 10 ft. outside of the furnace, where it is used while loading or unloading the car. Angle guides at the bottom of the furnace are hinged and counterbalanced so that when the car is in the furnace, the side and end joints are sealed. The furnace has an air-operated door, also lined with brick which is held in place by loose pipe, the brick being cut out on the edges to fit over the pipe. A supply tank is located outside of the building in the ground and piped to the furnace, the fuel being burned in shop-made burners. This furnace is principally used for repairs to the cast-iron cylinder heads which are still in service and require heating before and after welding operations are performed.

The pre-heating furnace shown in Fig. 2, size 48 in. by 72 in. by 21 in., uses charquets for fuel. The base of this furnace is designed with a ¾-in. top plate, perforated. The sides and ends are made from ¾-in. by 4-in. flat iron, on edge, with separators through the center making four compartments, and a ¼-in. plate on the bottom supported at each corner 6 in. from the floor by angle iron. Each compartment is piped for compressed air, having a clean-out. The sides and top are made from 1/16-in. sheet-iron, lined with asbestos mill board. These sides are supported at the center by tee iron which
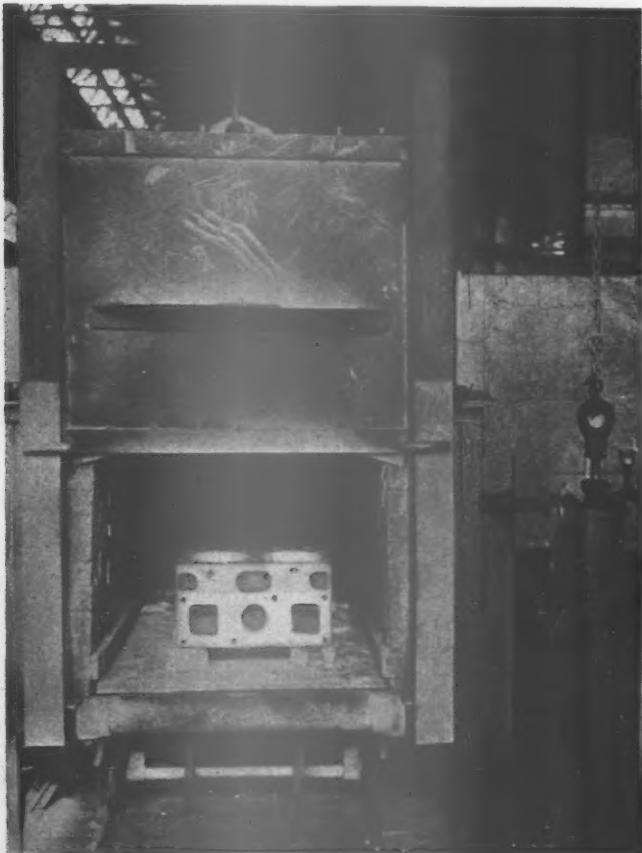

Fig. 1—Small car-bottom, oil-fired pre-heating furnace used in connection with cast-iron cylinder-head repair

Fig. 2—Shop-made pre-heating furnace fired by burning charquets under forced draft, and divided into four compartments, one or all of which may be used, dependent upon the size of the part

also carries the bars that support the furnace top. In using this furnace, one or more compartments can be used, depending on the size of the parts to be pre-heated.

Shape Cutting Locomotive Parts

The utilization of flame cutting for the fabrication of heavy parts in locomotive manufacture is extensive and growing steadily as new problems are met and solved through its use. Two recent, similar interesting jobs involved some rather unique ideas with regard to the handling of the shape cutting machine itself.

New designs of parts for the reverse lever mechanism for a certain type of locomotive required the solution of an interesting problem in shape cutting. These parts are known as "reverse lever arms" and "reverse lever crank arms." In each case the requirements for the shaping work were similar, and as a matter of fact the solution of one job, which was worked out first, gave the answer to the second. Essentially the problem was this:

The cutting operations had to be carried out in two planes. The first cuts were made on steel slabs 9 in. thick in the normal position, that is, with the slab lying flat on the material supports. The next cuts, however, were required to be made on the steel at right angles to the plane of the first cuts. When the material was first up-ended to make these next cuts, it was found that the cutting blow-pipe could not be raised sufficiently high. The machine was a standard one and ordinarily handles any but the infrequent, extreme job. The problem was overcome easily enough, however, merely by raising the cutting machine on some cribbing to the required height. It was then leveled off carefully and the work accomplished easily enough to set up the work on a production basis.

The first work was carried out on the part known as a "reverse lever arm." The rough sketches show the steps required for the formation of this part. Formerly this work had been done by a forging operation.

A steel slab 30 in. x 69 in. x 9 in. was procured for the raw material. The first of the three sketches shows the preliminary shape that was cut from the slab. This was a perfectly normal shape cutting job. The regular adjustments of the machine permitted easy handling of this, of course.

It was for the necessary second cuts in the plane at right angles to the first plane of cutting that required the raising of the cutting machine to a new level as described above. As it was necessary to set the steel up on its narrow edge to make these second cuts, it is obvious that considerable ingenuity was shown by the operator in reaching as simple solution to the problem as he did. It was, after all, a simple rearrangement of the machine, but one not generally thought about.
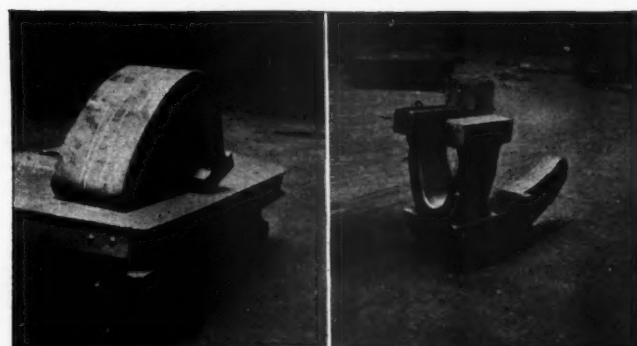

Left—After making the first cut for the reverse lever crank arm; Right—The completed part.

The third sketch illustrates the completed part after it had been finally bent and finish-machined to the final tolerances and to round out the pads and other parts. Incidentally, it is interesting to know that the heating for bending was done by the use of the oxy-acetylene flame.

The work on the "reverse lever crank arms," a similar part, was naturally enough patterned after that done on the "reverse lever arms." Some accompanying illustrations show these parts.

For these later fabricated parts the original steel slabs were 12 in. thick. The work was carried out in an exactly similar way as before. In connection with the preliminary preparation of the steel, it is worth noting that the entire surface of the steel was sand blasted before making any of the cuts. This precaution was made to eliminate any particles of oxide from flaking off and thus interfering with the smoothness of the cutting operation.
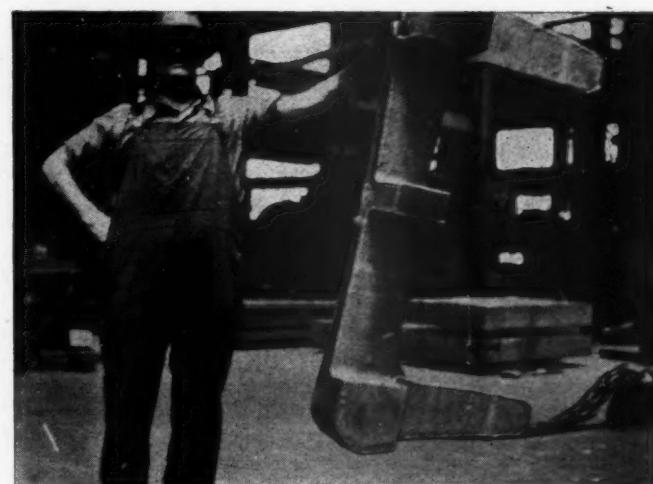
Three-dimensional shaping of this part eliminated an expensive forging job.
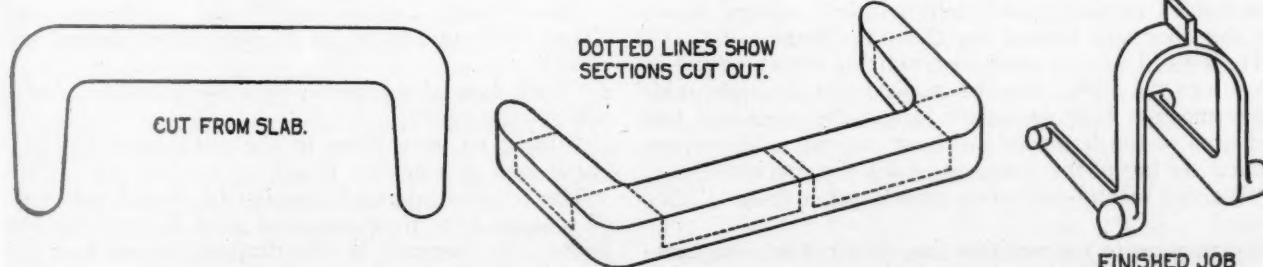
Three steps in the making of a reverse lever arm. Left—The first cut, made in 9-in. steel; Center—A rearrangement of the cutting machine simplified the second cuts; Right—The shaped steel was then heated with the blowpipe and bent to its final shape.

ROBBING PETER

"THE cost of turning engines at Plainville is running too high, much too high. It'll have to be reduced!" H. H. Carter, master mechanic of the Plains Division on the S. P. & W., raised his voice slightly. He could only be heard about a block away. When he got really worked up and going good he didn't really need a telephone for anything under a mile.

"Well, seems like we are doing the best we can," Jim Evans, the roundhouse foreman, replied, "but I'll see if we can't shave a little off of it."

"Try nothing—it's got to be done! If we run over our allowance about one more time, there'll be some new faces around here! . . . Now, about those engine failures. . . . "

Evans bit off a chew of horseshoe and braced himself. Carter hated engine failures worse than a machinist hates putting up binders.

"Now mind, we've got to cut the cost of turning engines and have fewer failures," the master mechanic admonished as he left the roundhouse an hour later.

"How are we coming on this month's showing?" Evans asked John Harris, the clerk, after Carter had left.

"Nearly three hundred dollars over," the clerk replied.

"Hell and high water!" Evans replied, "and this only the ninth. Well, I don't see how in the devil I'm going to cut much. I'll have some of the men charge time to classified repairs; that'll help a little." Evans strode out the door and headed for the roundhouse.

He noticed Cox, a machinist, and his helper sitting in the cab of the 5094. He also noticed that the right middle connection bushing wasn't in and the machinist had had time to finish the job without rushing. "How you coming on her?" the foreman asked the machinist.

"Waiting on the drill press man to get it drilled," Cox replied.

Evans went to the machine shop to see what was causing the delay. He found the drill press man sweating and swearing. Work was piled up all around him with more coming in all the time. Simpson, the drill press man, was working at top speed, but the drill press wasn't. Evans could almost count the revolutions of the drill as it turned.

"What's the trouble, Simpson? That fast as the drill will stand in brass?" Evans asked.

"Hell, no; but it's fast as it will run. The high-speed clutch won't hold and I have to run it at slow speed." The drill press operator was plainly peeved.

"Didn't we order some repair parts for the drill press some time ago?" the foreman asked.

"Yes, the storekeeper ordered them, at least he said he did, but they never did get here. If they did, I didn't see them."

Evans drowned a fly with a sluice of tobacco juice and started for the storeroom. "What's the trouble we can't get repair parts for the drill press?" he asked the storekeeper.

"Don't make 'em any more," the storekeeper replied. "That drill press is as out of date as red flannel underwear."

"Well, how about piston rods for a 5000? Are they out of date too?"

"Ought to have them in the next car. I'll let you know soon as I get the bills."

The foreman grunted a reply—his mouth was too full of tobacco juice to speak—and went back to the roundhouse. He stopped at the drop-pit to see how things were going there. Jenkins, a machinist, and his helper were wrestling with a boring bar in the right cylinder of the 5086.

by

Walt

Wyre

"Are you about to get her?" Evans asked the machinist.

"Well, it ought to fit at one end or the other. The blamed thing cuts tapering," Jenkins replied. "We've been on this pair of cylinders long enough to have bored half a dozen if we had the right kind of boring tool."

"Yeah, it's a little rough too." Evans leaned over and felt the inside of the cylinder.

"I'll say it's rough. By the time the tool marks are worn out, it'll need reboring again, but it's the best I can do with this boring bar. The blamed thing chatters like a model T in loose sand."

Evans went on down through the house trying to figure some way that cost of turning engines could be reduced. "Now, let's see; I might cut off a couple of laborers, a coppersmith, two machinists and helpers, and a boilermaker and helper. That'll be about forty dollars a day." Evans frowned and spat as though the cud of horseshoe in his left cheek had quinine in it. He turned suddenly and started towards the office. "Might as well have the clerk make the bulletin out and get it over with."

Evans instructed the clerk to make out the bulletin and put it on the bulletin board. "Might as well make the cut effective Monday. We have to give them forty-eight hours notice anyway and that'll just be one extra day not counting Sunday."

THE foreman sat down at his desk and was looking over work reports when Bart Hudson, the lead boilermaker, came in. "Say, Mr. Evans, the 5074 is due for a flexible staybolt cap removal. How about getting the jacket and lagging removed?"

"All right, all right!" Evans' voice sounded like Major Bowes talking to an amateur that had just gotten the gong. "Tell Malone to get on it right away."

Harris finished typing the bulletin, read it over, and started out the door with the paper in his hand.

"Hey, wait a minute," Evans stopped the clerk. "We'll have to change that a little. With that five-year test coming up on the 5074, I can't cut off a coppersmith or a boilermaker. Wait until tomorrow. Maybe something will come up." The foreman picked up a pad of yellow clip and began figuring. Three hundred dollars over already. A little over thirty dollars a day he was running over. That meant a reduction of about forty-five dollars a day if he stayed within the allowance for the month. Even if he cut off the two laborers and the two machinists and helpers that wouldn't near make it, just amount to about half of it, in fact. The foreman leaned back in his chair and propped his feet on the desk. He could think better in that position.

The phone interrupted his thoughts. "Roundhouse clerk talking," he heard Harris say. "O.K., I'll call you back and let you know what engine.—Old guess-and-grumble wants a 5000 for an extra west about twelve-thirty," the clerk told Evans. "What'll I give him?"

Evans' feet hit the floor with a thump. "I'll let you

Railway Mechanical Engineer
JUNE, 1936

know in a little bit soon as I look things over. May use the 5074; she can get back without running over her inspection date."

When Evans got to the roundhouse he found that the 5074 was out of the question. A boiler stud twisted off; wouldn't be time to get it without a delay.

"Well," Evans said to himself, "I'll use the 5081 and run the 5074 on the passenger instead." He walked down to stall fourteen where the 5081 stood. The piston valve out of the right side was lying on the front end of the engine. The valve bushing was lying on the floor nearby. There was a jagged gash cut with the carbon arc lengthwise of the bushing. Evans beat it to the machine shop to see if the new bushing was about ready to be put in.

It wasn't; in fact, work on it had not started. The casting was lying on the floor beside the lathe. Evans looked at his watch. Well, the 5081 was out, too. The engine on the extra would have to be run through or else the dispatcher would have to take a 2800. He went back to the office to tell him about it.

Evans sat on one corner of the desk and picked up the phone. "Say, how about a 2800 on that extra?"

The dispatcher sputtered like a piece of hot iron dipped in water. "No; couldn't make the time. Eleven coaches with a 2800? We'll have to use a 5000 and a blamed good one, too."

"Where you think I'm going to get one on such short notice? Think locomotives come in cans?" Evans asked.

"If they did, you fellows would have a delay hunting the can opener," the dispatcher cut in sarcastically. "And say, this extra is pretty hot stuff. A load of government officials, some of them high-powered, too. If you get a delay on it, I imagine you'll hear about it."

"What's coming in on her?" Evans asked.

"The 5083," the dispatcher told him.

"O.K., we'll just have to run her through. Notify the crew to stop the train by the roundhouse. Would you by chance be able to tell me definitely when to look for it?" Evans grinned slightly at his thrust at the dispatcher.

"Ought to be in at one-thirty-two and ten seconds." The telephone clicked as the dispatcher hung up.

"About as funny as a boil on the back of your neck —the dispatcher, I mean," Evans growled as he sat down at the desk. He still hadn't figured out how to save about forty-five dollars a day for the next twenty days and still keep engines going. Sitting and thinking wasn't doing any good, he decided, and went back to the roundhouse.

On his way through the roundhouse, Evans ran into two machinists with their helpers leaning against a locomotive talking. "What's this, a convention?" he asked.

"I'm waiting on machine work—valve bushing," Cox, one of the machinists, said.

"And I'm waiting to get a main rod bushing drilled," the other machinist told him.

"Well, see if you can't be doing something else while you're waiting."

Evans went to the machine shop. The drill-press operator was snowed under as usual, work to be drilled lying all around. But he was evidently doing the best that he could under the circumstances, so the foreman said nothing. Every machinist in the shop was busy. He walked over to the lathe where one of the men was taking a cut on a valve bushing. The cut being taken was very light.

"Last cut?" Evans asked.

"No," the machinist replied, "got to make one more. The lathe is just too light for this heavy work, and Martin is turning a piston in the big lathe." The machinist pointed to the machine mentioned, a belt-driven lathe that must have been a good one when peg top pants were in style.

Machine work was piled all around waiting to be done—rod bushings to be turned, a set of cross-head bolts in the rough to be finished and threaded, a main pin to be turned, among others.

A pair of babbitted crossheads lay waiting at the big planer. A machinist was making a piston-rod key in the big machine and a slow job it was, but the small slotter ordinarily used for such work had been broken down for several months. It was another heirloom handed down from some closed down backshop on the system. It had been in Plainville so long that Evans had forgotten where it came from.

Over at the boring mill a machinist was having some fun with a driving-box. The feed on the machine was worn out and had chosen not to run. Evans surveyed the scene a few minutes, then, seeing there was nothing that he could do to help the situation, went back to the office.

"The dispatcher said for you to call him," the clerk told Evans.

Evans swore and picked up the telephone.

"The 5083 is falling down," said the dispatcher. "The engineer says she's not lubricating; wouldn't pull a relief worker loose from his shovel. How about digging up another hog?"

"There ain't another one," Evans replied, "unless you could use a 2800."

"We don't run trains by the calendar," the dispatcher retorted.

"Hell, no! A calendar is always right!" the foreman snapped. "We'll just have to see what can be done with that lubricator while she's being worked," Evans added and hung up.

"Now ain't that nice!" he told the clerk. "Me trying to figure out how to save forty-five dollars a day with no prospects for saving a penny without neglecting work that should be done and an engine failure staring me in the face. Well, that's that! Guess I'll go eat; maybe things will look better."

The foreman left word for a machinist and helper, the cellar packer and rod cup man to work through noon hour to get the 5083 when it came in on the Special. He rushed back from lunch so that he would be there when the engine came in. But things didn't look any better. The 5083 was steadily getting worse and losing time. The Special wouldn't be in until about one o'clock. "And all that extra time from working the men noon hour, too," Evans growled.

Just as the one o'clock whistle blew, the smoke of the extra showed in the distance. It was ten minutes past one when the engine reached the roundhouse.

"How's she doing?" Evans asked the engineer.

"Not worth a damn! She's not lubricating, the cylinders are dry and blowing bad."

"Why didn't you add some oil?"

"I did, when we stopped for water at Middleton. She done very well for awhile. The trouble is the oil gets too hot, boils and foams. Ought to use saturated steam instead of that superheated steam from the turret to heat the lubricator. Everything else looks pretty good," the engineer added.

Evans fished in his jumper pocket for his plug of horseshoe. His brow wrinkled and he squinted one eye.

He found the chewing tobacco and bit off a hunk. "Disconnect that pipe at the lubricator connection," he told the coppersmith, "and put a choke in the line. Leave about a sixteenth of an inch opening for steam."

While the coppersmith was fixing a plug to fit the lubricator steam pipe connection, the lubricator was filled. Evans pumped oil to the cylinders by hand and then told the supply man to replace the oil he had pumped out of the lubricator.

The engine was serviced and ready to go when the coppersmith returned with the choke he had improvised

Evans surveyed the scene a few minutes, then, seeing that there was nothing that he could do to help the situation, went back to the office

for the steam line. He had cut a washer that would fit in the connection and drilled a 1/16" hole in it.

"What do you say?" the engineer asked. About ready to go?"

"Yes, go ahead and get on the train," Evans replied. "Ride down with him and connect up the lubricator heater pipe while they're testing the air," he told the coppersmith.

"Think they'll make it?" the clerk asked when Evans reached the office.

"Well, I don't know. Might, if that hoghead will use a little judgment. I gave him some extra oil and put a choke in the lubricator steam line. It ought to work

O. K. At least, I hope so," the foreman said fervently. "If it does, I've still got the allowance to worry about. If it don't make it, I wouldn't be surprised if I didn't have a new job to worry over—how to get one, I mean." He left the office and went over to the roundhouse.

Things were going somewhat better than they had been before noon. The men in the machine shop had gotten out enough of the accumulated work so that the ones on running repair could get to work, and they were working, Evans noticed with a feeling of satisfaction. But that didn't reduce the cost of turning engines.

WHEN it came time to go home at seven o'clock that evening, the foreman still had figured no way to make a substantial reduction. The next day was a repetition of the one preceding. Men on running repair tore the work down, then waited on machine work.

About two-thirty, the master mechanic called up and told Evans to come down to the office. The foreman gathered up an armful of files and correspondence on things he thought possibly Carter would want to know about and headed for the office.

"Well, have you figured out how you can cut down within your allowance?" the master mechanic asked.

"Not enough to do any good. Of course, I can cut a dollar here and there——"

"Why can't you cut down? Other railroads are doing it. We ought to be able to turn engines at a cost to compare with them. Look here." The master mechanic shoved a typewritten chart showing comparative costs of turning engines of various railroads at roundhouses somewhat similar to Plainville.

Evans studied the chart a moment before replying. "Yeah, we're a lot higher than some of them. Wonder if the ones showing low costs hitch horses to their automobiles?"

"What do you mean?" Carter snapped.

"Well, I might as well let you have what I'm thinking now as later," Evans said hesitatingly. "That's what we're doing here on the S. P. & W. We've got some good locomotives, some of them fairly new and I understand they are buying some more new model streamlined equipment, right up to now. But, in our roundhouse, we're still driving a horse."

"What are you getting at? Talk sense," the master mechanic snapped.

"Well, to be perfectly frank, we are trying to make repairs on new style motive power with old style equipment. We're doing it, too, and a good job if I do say it, but we could do a blamed sight better job if we had tools in line with the work we are doing."

The master mechanic listened while Evans explained the situation. When the foreman had finished, Carter

said, "Yes, we need new tools, new equipment, but I don't see how we are going to get it.

"But what I wanted to talk to you about is the company is spending a lot of money on track repairs, over two million dollars getting ready for faster trains. They are sending some machines up to be overhauled, a pile driver, a couple of tie tampers, and a ditcher. Want to get them soon as possible."

"O. K., we'll get them." He grinned just a little as he said it. He had found a way out of his overrun allowance. "And I think I can make some reduction in cost of turning engines, but remember about the machines we need."

"All right, I'll remember, and don't charge so blamed much time to them track machines that the division engineer will think he's getting new ones." The master mechanic had been a foreman himself.

Inspecting and Repairing Oxy-Acetylene Equipment

Repairs to oxy-acetylene equipment on the Pennsylvania System is centralized at Wilmington, Del., Altoona, Pa., Pitcairn, Pa., and Columbus, Ohio. These repairs for the Central Region are taken care of at the Pitcairn Air Brake Shop. Repairs of any nature are not permitted at outlying points, instructions being to the effect that the equipment be forwarded to the designated shop for the necessary repairs. Regulators must be sent in every six months, and torches at such time as they fail to function properly. For identification purposes, and as an aid in tracing shipments, the triplicate repair tag, mentioned in the article on pneumatic tools, which appeared in the January *Railway Mechanical Engineer*, page 32 is used.

Regulators

Various types of regulators are in service, but a description of the methods and practices for any one type will suffice. When regulators are received for repairs, an inspection is made previous to dismantling, for the following: Nipples broken off at connection to body; inlet connection nut worn or so damaged as to prevent holding the regulator tight on the cylinder valve; inlet connection gland loose at the filter, or with bent, broken, or damaged seat so it will not make a tight joint with the cylinder valve; filter loose at the connection to the body or to the adapter or filter bent or damaged so as to cause it to leak; safety-valve stud loose at body connection, or bent or broken; bottom cap damaged so as to prevent removal without injuring the regulator body; spring case loose or threads stripped so as to prevent holding an adjusting screw.

When dismantled, the parts are cleaned with turpentine substitute or tetrachloride, extreme care being taken not to permit oil or grease to get on any of the parts or connections. The gages are removed and tested on a test rack. As a coating of litharge mixed with glycerine in the form of a paste is applied to the connections at the time of assembling, it becomes necessary to heat the connections by means of a welding flame in order to effect their removal from the regulators.

The bottom cap is removed by holding it in the vise and turning the regulator body to the left by hand. A light jar with the hand on the filter assembly will loosen the joint, care being taken not to tighten the vise sufficiently to crush the cap. The adjusting screw is turned to the right until the pressure on the stirrup cap is released, then the stirrup cap is removed with a screw driver, following which the equalizing pin seat and holder and spiral seat spring are removed. In case the seat and holder stick, they can be pulled out with the eraser on the end of a lead pencil. If the spring case threads are stripped, so that a good adjusting screw will not hold, the threads are drilled out, and a shoulder bushing sweated in place, which brings the threads back to the standard size again, so as to fit a standard screw.

In case the threads in the spring case are pulled or otherwise damaged, they are retapped with a ½-in. 13-thread U.S.S. tap. The usual procedure is to clamp the tap in a vise with the regulator above it, thus turning the regulator on the tap. This method is used as an aid in preventing chips from lodging in the regulator body. If the ball seat of the adjusting screw is dirty, nicked or badly worn, it is cleaned with No. 00 emery cloth. Such conditions cause the gage hands to vibrate and must be eliminated. Bent screw handles are straightened by means of a wooden mallet. The inlet nut and swivel, as well as the hose connections, are renewed, if damaged, the nipples being sweat soldered in place. The hose-connection gland seat, if damaged or leaking, is reseated with a reamer which is lubricated with thick soapy water during the operation and litharge and glycerine is applied to the threads when it is placed in the regulator body.

Special attention is given to the fit of the valve holder in the nozzle. If it is tight, it is dressed with fine emery cloth, and if ridges appear in the nozzle bore, the nozzle is renewed. These defects, as well as that of the stirrup binding in the back cap, causing friction, will result in what is known as "zero leak," "hum" or "excessive static creep" of pressure.

Repairs to the valve seat in the holder are made by placing the holder in a small bench lathe, facing the seat true, polishing with a piece of crocus cloth, and buffing with a rag. If the seat is in fairly good condition, it


Test device used in determining leakage in regulators

may be cleaned with an ordinary eraser. The nozzle seat, if necessary, is reamed, faced with a piece of crocus cloth rolled, and finished with a piece of cloth. An eraser is used in case the seat is in good condition. The compensating spring is carefully inspected, and if weak or corroded, is renewed. Building up of pressures beyond the adjustment of the regulator results if the defects mentioned are not taken care of properly. The equalizing pin is inspected for worn or flattened ends and hammered sides and it is renewed if damaged to any extent. If the stirrup cap has more than one central impression for this pin, or if the stirrup cap is otherwise damaged, it is renewed. The stirrup is carefully examined for bulging sides, stripped threads, or damaged wedge-shaped ends. The nozzle hole is gaged to determine whether or not it is the proper size. These sizes on cutting and welding regulators are ⅛ in. diameter and ¹⁄₁₆ in. diameter for cutting and welding, respectively.

Particular care is exercised to see that the stirrup and stirrup cap do not drag in the bottom cap, and that the

gasket shoulder on the cap is in good condition. A new type of compensating spring, known as the spiral-seat spring has been developed, as an aid to prevent "humming" at certain pressures. This is installed with the small diameter toward the nozzle and the large diameter toward the seat, the coil end being bent inward sufficiently to prevent scraping or binding on the nozzle sleeve. The safety cap is inspected to see that the threads are in good condition, the disc shoulder not damaged, and cap not plugged up. If the safety-valve seat is rough or corroded it is cleaned with crocus cloth. Following repairs and previous to assembling, regulators are blown out with filtered compressed air free from oil or moisture.

Assembling Regulators

The spiral seat spring is placed, as previously stated, with the small diameter toward the nozzle, in the nozzle sleeve. The seat and the holder are put in position, with
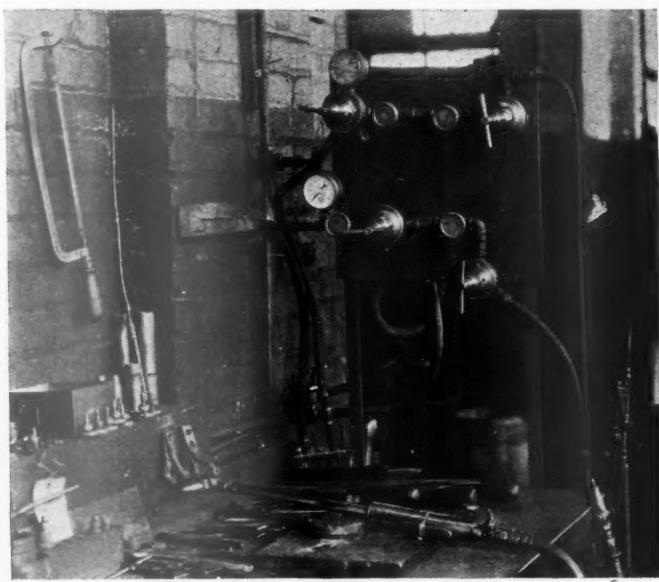
Bench and test rack used in repairing regulators

the black seat to nozzle, and is pushed down on the nozzle and then released, to see that the parts are free. The adjusting screw is inserted for a few turns and the regulator held with the nozzle and stirrup pointing upward. The equalizing pin is placed in the holder and stirrup cap screwed down on the stirrup. As the stirrup has split ends, particular care is required in order to avoid crossing the threads, the projecting ends of the stirrup being held together sufficiently to obtain a full thread for the cap and, when screwed up, the wedge ends of the stirrup are held tightly in the vee joint of the cap. The regulator is then held in such a manner that the equalizing pin will center in the cap, so that the cap will not catch on the nozzle sleeve end. The stirrup cap is then tightened with a screw driver and the adjusting screw released so that the nozzle will move with a slight touch of the fingers. The stirrup is twisted back and forth to make sure that it does not rub on the nozzle bridge. The bottom cap gasket is moistened with water and placed on the cap, which is then placed on the regulator body and turned back and forth a few times, to insure that it does not bind on the stirrup or stirrup cap. The regulator is now placed with the cap held in a vise, and the regulator body tightened on the cap by hand. An examination of the safety valve is made to make certain that the proper disc is applied, and that the ports in the cap are open. Pressure gages which have received the necessary test and repairs are placed on the regulator

connections, an application of litharge and glycerine being put on the threads.

Testing Regulators

Testing equipment consisting of three oxygen cylinders is used for testing regulators, one for oxygen regulators, one for acetylene regulators, and the third for the purpose of re-checking low-pressure gages when necessary and for making a soap suds test for diaphragm leakage on certain types of regulators. A short hose connection is used, one end of which is attached to the outlet of the test rack regulator and the other end to the outlet of the regulator on test, permitting an outlet from the cylinder to the low pressure gage. When the pressure in No. 1 cylinder has been reduced to 1,500 lb., it is replaced by a full cylinder, and the partly used cylinder takes the place of No. 2 cylinder when that one becomes empty.

The procedure in testing oxygen regulators is as follows: The regulator to be tested with the tension released on the adjusting screw is applied to No. 1 cylinder, and the cylinder valve opened slowly. A soap bubble is now placed on the regulator outlet connection to determine whether or not a "zero" leak exists. This would be due to the regulator seat leaking, and if an examination shows that the seat is in good condition, the cause of the leakage is probably due to the seat being low, which can be corrected by placing layers of writing paper beneath the seat to bring it to the desired height.

A test device is next attached to the outlet of the regulator on test. Tension is put on the adjusting screw until a pressure of 30 lb. registers on the gage of the test device. Sufficient time is allowed for the pressure to settle, and the gage is watched for any increase in pressure for a period of three minutes, which increase should not be over 5 lb.

A decrease or increase in pressure at this time is caused by the diaphragm leaking, or parts in the valve or nozzle assembly binding or rubbing, which serves to prevent the valve from seating properly. If the diaphragm is of the soldered metallic type, a test is made as follows: Remove the adjusting screw and spring case, attach outlet end of regulator to the outlet on No. 3 cylinder by means of a hose connection. Pressure is then turned on and is against the diaphragm. Any leakage can be detected with the aid of soap suds. This method also has the desirable effect of resetting a diaphragm which has buckled, due to the fact that the pressure strikes the diaphragm in an opposite direction than when operating normally. If the diaphragm is one of the composition type, a visual inspection will determine whether or not it is in good condition.

Acetylene regulators are tested on No. 2 cylinder and the above practices prevail, except that not over 200 lb. pressure is used during the tests. Soap suds is applied to regulators during the tests and all leakage eliminated. After passing tests regulators are prepared for shipment as follows: The adjusting screw is removed and wired to the regulator; the inlet connection is wrapped with heavy paper to prevent dirt from getting into the regulator, and the regulator is placed in a wooden container for shipment.

Approximately 300 regulators are repaired each month at the Pitcairn Shop.

Repairs to Torches

Various types of torches are repaired, but a description of the practices on any one type will suffice, as the principle is practically the same on all types. There is no specified period of time for torches to remain in service, but they are sent to the central shop at any time

that they fail to function properly. As in the handling of regulators, a repair tag is used to facilitate shipping and identification of the sending shop. When received at Pitcairn they are carefully inspected for the following: Leaking valve seats; leaks at soft soldered connections on the base; leaks at the hard soldered connections on the tip head; leaking tubes; leaks at the valve-stem packing glands or nuts, hose-connection inlet gland, or tip retaining nut in the tip head.

Careful attention is given the tapered seats in the tip head, to make sure that they are free from dents or distortion. A test for leakage is made in the following manner: The oxygen and acetylene hose on the testing device are connected to the torch, pressure adjusted, flame lighted on the tip end, and the torch submerged in a water bath. Bubbles will reveal the sources of any leaks which may exist while the fact that the torch body is submerged, prevents any danger of explosion due to leaks in the open. Following test and inspection the torch is dismantled in approximately the following order: Tip and retaining nut, valves in base, high-pressure unit, base removed from the tubes and the handle assembly taken from the tubes. Damaged needle-valve seats are reamed by means of a flat-bottom reamer which insures proper alignment of the seat with the stem of the valve. Screw taps are used to clean dirt from and relieve strain in the threads. A drill or wire of sufficient size is used to remove dirt or other foreign substance from all by-passes and compressed air, free from oil or moisture, is blown through to remove fine particles. Damaged valve stems are replaced and all valve-stem assemblies are packed with $1/8$-in. standard graphite packing. Damaged high-pressure valves at the nozzle are reamed with a special tool and damaged seats are replaced. Oxygen and acetylene hose connections, if damaged, are replaced with new ones which are screwed into the base and flame-soldered.

Tubes and Head Assembly

By-passes are cleaned as previously described, with a drill or piece of wire and blown out with compressed air. Bent tubes are straightened and, if, bursted, are withdrawn and replaced, all tubes being hard (silver)-soldered to the tip head, due care being taken to see that the pre-heat gas tubes as well as the acetylene supply tubes are of a copper alloy.

The supply tubes in cutting torches are, as a rule, not less than 14 in. long, to insure safety and comfort to the


A repairman's bench showing the tank in which torches are submerged while being tested for leaks

270

operator. Any necessary reaming is performed on the tip head seating surfaces, when dented or distorted, while suitable screw plugs and taps are used to repair threads in the tip head and tip retaining-nut screw threads. Damaged tip retaining nuts are replaced. All bent or broken handles are reclaimed by straightening or welding, if their condition so requires.

Torch Tips

All tips are carefully examined for clogged by-passes, marked seating surfaces, strained and stripped screw threads, being bent out of alignment, and as to the condition of the hexagon wrench hold on the body for tightening the tip in the head. The by-passes on the flame
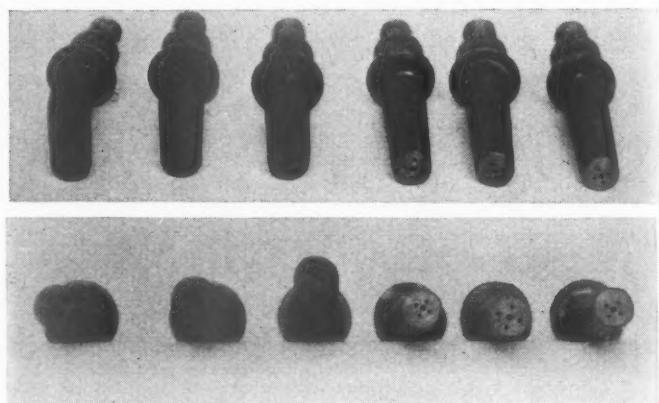
Two views of defective torch tips as received for repairs (three at left) and after having been repaired (three at the right)

end of the tip are checked to conform to standard sizes. Clogged by-passes are cleaned with a drill of such size as will not enlarge the opening. Bent tips are straightened with a hammer, while those having strained or stripped threads are renewed. The removal of marks on seating surfaces and the cleaning of the bodies is accomplished by means of a high-speed motor equipped with suitable fixtures to fit the tips, a buffing and emery process being employed.

Orifices in the flame end of tips which are oversize are wedged and re-drilled to the proper sizes, and the orifices in the gas mixer end are cleaned. All tapered seating surfaces on the gas mixer end are freed of marks, or anything that would interfere with the tight seating of joints, so necessary for the proper functioning of an efficient torch tip.

Torch-Tip Head

The joints are soldered with silver solder to guarantee tight joints at high temperatures. The tapered seating surfaces in the tip head become distorted and coated with carbon. This condition is remedied by the use of a tapered reamer, soapy water being used as a lubricant for cutting. When the tip retaining-nut screw threads in the tip head become strained or distorted, they are repaired by means of a screw plug of the proper size, the outside of the thread connection being hammered to re-form it to shape.

Assembling Torches After Repairs

After the repairs are completed the torch parts are assembled in the following order: The handle grip and tube; tube assembly and base (soft-soldered with acetylene flame); hose-connection glands and base (soft-soldered with open flame); oxygen and acetylene needle-

valve-stem assembly; handle-grip assembly adjusted to tubes and base (using machine screws to hold them in place); high-pressure trigger-valve handle replaced and adjusted; tip and tip-retaining nut fitted to head.

Testing Torches

When the torch has been assembled, the oxygen and acetylene hose on the testing device are connected to the torch. Pressures are adjusted and the torch lighted in the following manner: The oxygen valve is opened and left open; the regulator valve on the test device is opened slowly until the pressure gage shows the correct working pressure, then the oxygen valve on the torch is closed. Next, the acetylene valve on the torch is opened and left open; the acetylene regulator valve on the test device is opened slowly until the low-pressure gage shows the correct working pressure. The torch is lighted and held in a downward position and not in the direction of other workmen. (*The acetylene is always allowed to flow through the torch for two or three seconds before applying the lighter to the tip in order to avoid back firing.*)

Next, the oxygen valve on the torch is opened and the flame adjusted.

A test is made for leaking joints by submerging in a bath of water. If leaks occur, proper adjustment is made at the packing nuts, soldered joints, and tapered seats in the tip head. The character of the flame is noted, as all cutting tip and pre-heating flames should burn uniformly. The trigger handle is pressed, and while the oxygen flame is burning from the orifice in the center of the tip, it is noted whether or not it travels in a straight line with the tip.

Tests, Causes of Trouble, and Remedies

1—*Nature of trouble*—Low-pressure gage shows correct pressure, but sufficient acetylene does not come through torch.
Reason—There is probably carbon in the mixer.
Remedy—Remove the mixer and clean it with soft annealed wire.
Reason—Possibly carbon in the valve.
Remedy—Clean the valve carefully, using only soft annealed wire.
2—*Nature of trouble*—Low-pressure oxygen or acetylene gages show correct pressure, but sufficient gas does not pass through torch.
Reason—Possibly dirt in the screen.
Remedy—Remove and clean the screen.
3—*Nature of trouble*—Oxygen leaking through the center orifice in the cutting tip when the cutting valve is closed.
Reason—Valve seat is leaking.
Remedy—Clean the valve seat, and if this does not correct the trouble, reseat or renew the seat.
4—*Nature of trouble*—With correct pre-heating flame on the cutting torch, flame is blown out when cutting-jet valve is opened, or the torch shows an oxidizing pre-heating flame.
Reason—Leak at the tip seat in the torch head.
Remedy—If the tip cannot be reseated, apply a new one. In an emergency out in the field, it may be possible to remedy this defect by chalking the tapered seating surfaces, which has the effect of filling up the crevices.

Following the tests, the torch is shut off as follows: The oxygen valve on the torch is closed first then the acetylene valve, after which the cylinder valves are closed. The torch valves are then opened to release the pressure on the gages, after which the regulator-valve screws are released. After this is done the torch is turned over to the stores department for shipment.

Approximately 80 torches a month are repaired at the Pitcairn Shop.

Hose and Hose Connections

Leaking hose or connections are not used, as a small jet of oxygen striking a workman's clothes may cause them to ignite from a spark and result in a severe burn. Hose and connections are tested daily for leakage, after the pressure has been properly adjusted to the torch, by closing the cylinder valves, keeping the torch valves closed, and noting whether or not any drop in pressure occurs on the high-pressure gage. If such a drop occurs, the leak is located by the use of soap suds, testing the hose, torch, and connections.

Hose connections are coated with shellac before being placed in the hose, and are well secured with clamps. A hose that has been used for acetylene is not used for oxygen, and vice-versa.

In case of a back fire in a hose, the cylinder valves are closed immediately, the acetylene first. With the valves closed, the hose in which the back fire occurred, is disconnected from the regulator and torch and laid aside for 20 min. at least. If, at the expiration of this time, the hose is cool to the touch, and there is no smoke issuing from it, or any sound or other indication of fire in it, the hose is blown out with compressed air, first making sure that the air is free from oil or moisture, after which the hose is allowed to remain for about 20 min. longer, at which time, if there is no indication of fire, it is placed in service. As a rule, hose in which a back fire has occurred will contain burned rubber, which may be carried to the torch screen or valve, resulting in clogging of the torch. It is often necessary to cut out the burned section.

Regulators and Gages

High-pressure regulators and gages are used on all cylinders from which gas is being used, and low-pressure regulators and gages on all welding or cutting connections to generator pipe lines. Regulators and gages which have been used for oxygen are never used for acetylene and vice-versa.

Particular care is exercised to prevent grease from
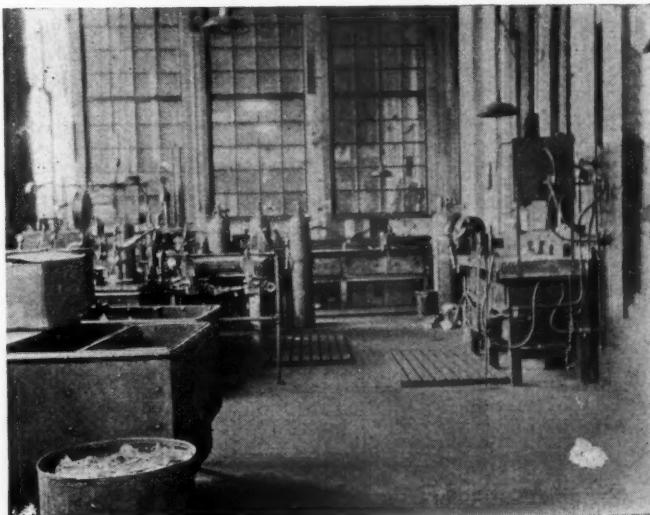
A general view of the department where oxyacetylene equipment is repaired

getting in or around the regulators, gages or fittings, as the oxidization which occurs when oxygen comes in contact with oil or grease may cause a fire or an explosion. Regulators with broken glasses are taken out of service and sent to the shop to be repaired. Welders and cutters are not permitted to make repairs.

Supervisors are required frequently to inspect gages showing working pressure, to see that the hands have not been sprung back, allowing considerable pressure of gas to pass through the gage before it starts to register, permitting workman to use higher pressure than that shown on the gage.

The 2,400-hp. two-unit Diesel-electric locomotive for one of the Union Pacific's new nine-unit articulated trains

NEWS

Colonel B. W. Dunn Dies

COLONEL B. W. Dunn, who retired on February 1, 1935, as chief inspector, Bureau of Explosives, Association of American Railroads, died on May 10 at his home in New York. He was 75 years old.

Streamliner City of Los Angeles Delivered

THE streamliner City of Los Angeles of the Union Pacific was completed and sent out of the shops of the Pullman Standard Car Manufacturing Company on April 21, and after being exhibited in Chicago on April 22 and 23 departed for Los Angeles, from which city it began its 39¾-hr. schedule on May 15.

How Fast Are We Going?

THE use of speedometers in the solariums of the streamline trains and in day coaches of some other through trains is the latest novelty offered by the Boston & Maine. The first train to be so equipped will be the "Flying Yankee," between Boston and Portland, and beyond over Maine Central lines to Bangor, Me. The speedometer will be illuminated, and will have a clock included on its face.

All Available Automobile Cars Being Used

ALTHOUGH the railroads have been steadily increasing their supply of cars suitable for shipping automobiles, "all of such cars as well as the highways and water routes" are being used just now "to the limits of their capacity" to care for the current factory sales of automobiles, according to a recent statement issued following a meeting at Detroit, Mich., of the traffic managers of companies affiliated with the Automobile Manufacturers Association. The foregoing followed a reference to reports received at the meeting which "indicate that thousands of freight cars formerly used in transporting automobiles are no longer in service."

Mechanical Division Announces Meeting Place

THE Mechanical Division, Association of American Railroads, has announced that the 1936 annual meeting, scheduled for June 25 and 26, will be held at the Congress Hotel, Chicago. The meeting will convene at 10 a.m. Eastern Standard Time on the first day and 9 a.m. on the second day. The program will be completed by noon on June 26, if possible.

Boilermakers To Meet in September

THE annual meeting of the Master Boilermakers' Association will be held at the Hotel Sherman, Chicago, September 16 and 17. It will be strictly a business meeting at which a revision of the Constitution and By-Laws of the association will be discussed, as well as subjects of papers for later presentation.

Chicago-Denver 16 Hours

THE Chicago, Burlington & Quincy, on May 31 established 16-hr. daily train service between Chicago and Denver, when it transferred Zephyr No. 1, then operating between Lincoln, Neb., and Kansas City, Mo., and its Mark Twain, then operating between St. Louis, Mo., and Burlington, Iowa, to the Chicago-Denver line. These trains will be operated between Chicago and Denver until the 12-car Denver "Zephyrs" are completed about the latter part of July. This move is an effort on the part of the Burlington to capitalize on summer business and to protect its Chicago-Denver mail contract. The time table provides for departure from Chicago at 5:30 p.m. and arrival in Denver at 8:30 the next morning (1,034 miles at 64.63 m.p.h.). Departure from Denver will be 4:00 p.m. and arrival in Chicago at 9:00 a.m. The trains will be known as the Advance Denver Zephyrs.

The former service provided by these trains is now furnished by steam trains.

"Super Chief" Placed in Service

THE "Super Chief" of the Atchison, Topeka & Santa Fe was placed in service between Chicago and Los Angeles on May 12, on a schedule of 39 hr. and 45 min., leaving Chicago at 7.15 p.m. Central Time. Its inauguration was celebrated by a triple birthday party held in the Dearborn Street station just before departure, the occasion being the birthday of the new train and the anniversaries of Samuel T. Bledsoe, president of the Santa Fe, and his daughter, whose birthdays fall on May 12.

R. & L. Historical Society to Hold First New York Dinner

THE New York Chapter of the Railway & Locomotive Historical Society will hold its first annual dinner at the Columbia University Club, New York, on June 11. The members are to be entertained with moving pictures of some of the country's fastest trains and an exhibit of model locomotives to which the Baltimore & Ohio is to contribute.

New York Central Streamliner "The Mercury"

THE New York Central's new streamline high-speed train to be placed in service on a daily round-trip schedule between Cleveland, Ohio, and Detroit, Mich., via Toledo, Ohio, will be named "The Mercury."

The train, air-conditioned throughout and embodying many innovations in appointments and mechanical features, will be placed in service some time this month following an exhibition tour covering several cities. Especially in its floor plan and decorations will The Mercury differ materially from any existing train. Its seven, full dimensioned cars are constructed of steel but will be substantially lighter than present standard equipment. The Pacific locomotive was streamlined in the railroad's shops at West Albany, N. Y.,
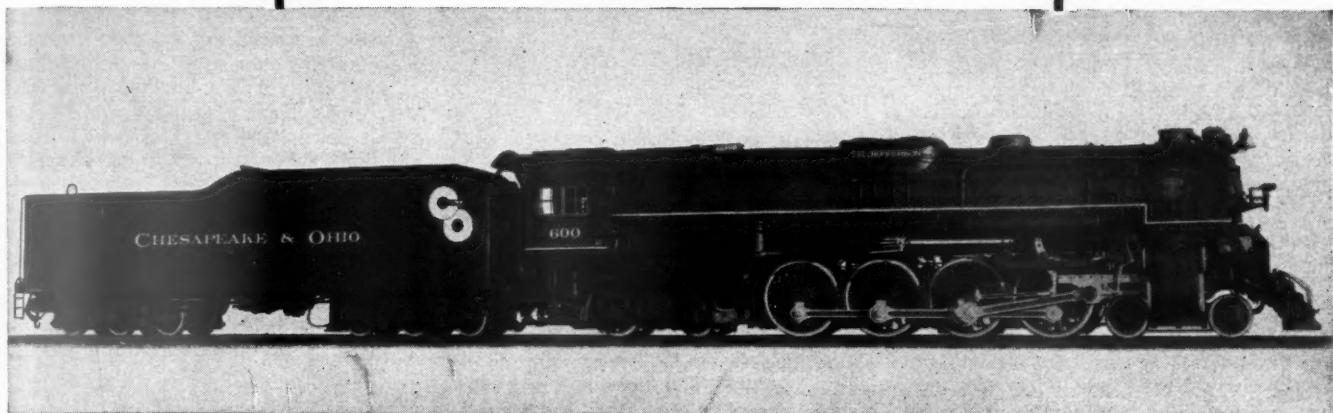
and the cars have been under construction in the Big Four shops at Beech Grove, Ind.

Everything in The Mercury, including fabrics, furniture, china, and glassware, has been designed especially for it. The train will be entirely free from uncontrolled slack, thus doing away with jolts in starting and stopping.

The cars will consist of a combination baggage car and coach, a coach with smoking room for men and women, a full length diner with new seating arrangement, a pantry-kitchen car, a lounge bar car, a parlor car and parlor-observation car with streamline rounded rear end, into which is built an electric sign bearing the train's name.

The Mercury's locomotive, which, like the cars, will be painted a dark gray with silver striping, will have roller bearings on its truck, trailer and tender axles. These will be used also on the axles of each car. A feature of the locomotive will be the permanent illumination of its 79-in. disc driving wheels and their silvered rods by floodlights concealed beneath the streamline covering.

A Million Miles of "Zephyrs" on the C. B. & Q.

ONE million miles of Diesel-powered "Zephyr" service on the Chicago, Burlington & Quincy were completed on May 27, and the achievement was celebrated at a luncheon of the Chicago Association of Commerce on that day. The actual millionth mile was run by one of the "Twin Zephyrs" operating between Chicago and the Twin Cities near Savanna, Ill., at 12:55 p.m., while the luncheon was in session at Chicago. Through a National Broadcasting Company radio hook-up the sound of the train as it set off torpedoes and ran through a 21-ft. hoop of paper were transmitted to the luncheon gathering at Chicago. Speakers at the luncheon were H. L. Hamilton, president of the Electro Mo-

tive Corporation; Edward G. Budd, president of the Edward G. Budd Manufacturing Company; Ralph Budd, president of the Burlington, and Charles F. Kettering, president of General Motors Research Corporation. The celebration was climaxed by a motion picture showing the train passing through the hoop of paper at Savanna.

Green Diamond on Good-Will Tour

THE Green Diamond, streamline train of the Illinois Central, following a goodwill trip through the southwest, the Mississippi Valley and the great lakes region, and a series of test runs between Chicago and St. Louis, was placed in regular service between these cities on May 17.

During this 7,000-mile good will tour approximately 2,000 persons an hour passed through the train at every stop.

Report of Mechanical Advisory Committee

THE Mechanical Advisory Committee, appointed by the Federal Coordinator for the purpose of co-operating with his Section of Transportation Service, has recently completed a report of seven typewritten volumes covering practically every important phase of the modernization of railway equipment. The interest in and value of this report is such that the General Committee of the Mechanical Division is considering the advisability of printing and distributing it in a single volume of 850 to 1,000 pages, at a cost of $8.00 to $10 a copy, depending upon the number printed.

Both the present and the future requirements of mechanical equipment and motive power designed to meet the needs of railroad shippers and travelers are considered in this report which covers the following general subjects: Steam locomo-

tives; oil-electric locomotives; electric locomotives and electrification of railroads; freight cars; reduction of tare weight; evaluation of light weight; development of passenger car design; materials and methods of construction; rail-motor cars; and container cars.

According to a circular letter recently issued by the secretary of the Mechanical Division, this report will be available to members at the cost of printing, and to non-members at twice this price. Those who desire copies are requested to advise the secretary, V. R. Hawthorne, 59 East Van Buren street, Chicago.

## Experimental Construction of Tank Cars Authorized

UPON reconsideration the Interstate Commerce Commission has granted authority which it had previously denied to the Union Tank Car Company to construct for experimental service 15 tank-car tanks fabricated by the fusion welding process and to use in experimental service 10 tanks already constructed. Similar authority was granted to E. I. duPont deNemours & Co., for the construction of one tank of nitric acid resistant metal by the fusion welding process and to the Phillips Petroleum Company to construct 25 tanks by the fusion welding process.

National Machine Tool Builders Association Honored

THE National Machine Tool Builders Association has been presented the American Trade Association Executives Award for the outstanding achievement by a trade association during the past three years. The presentation was made by Secretary of Commerce Roper to Herman H. Lind, general manager of the National Machine Tool Builders Association, at a recent

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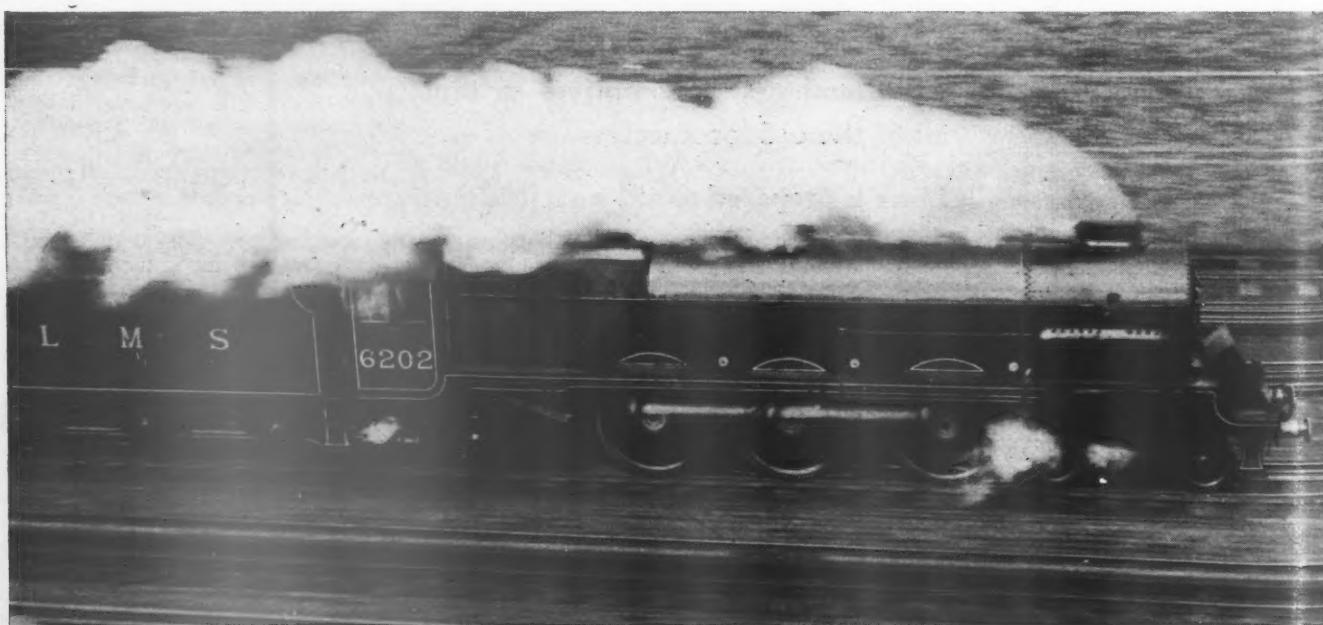
Globe photo

The London, Midland & Scottish turbine locomotive hauling the "Royal Scot" over Bushey water troughs on her way north—For a description of this locomotive see the February *Railway Mechanical Engineer*, page 53

A SAVER
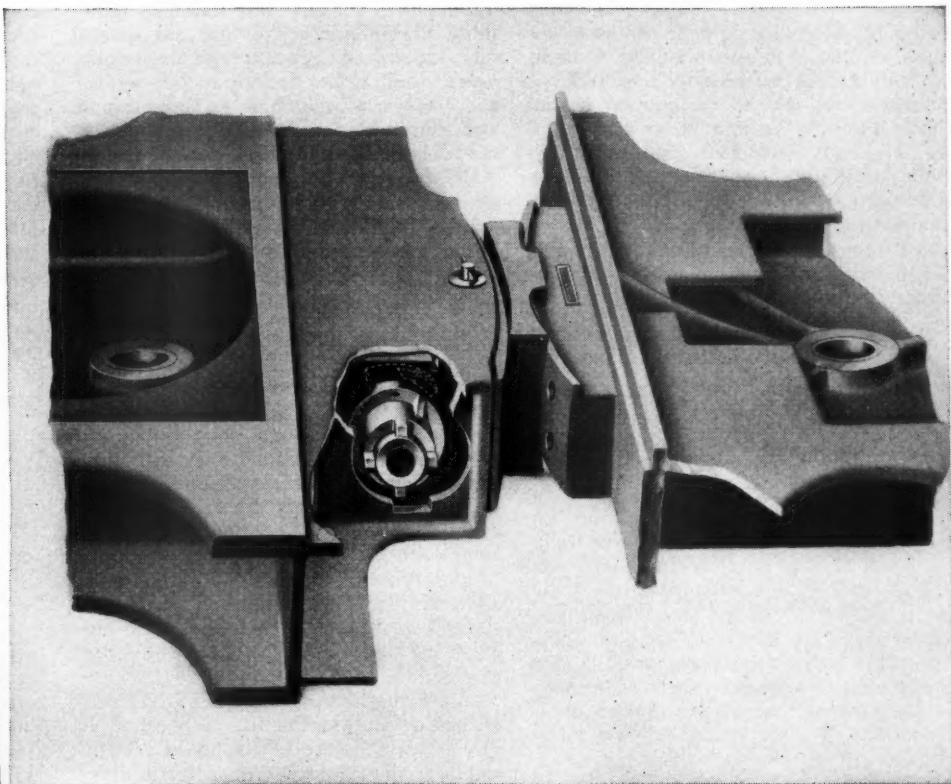
RADIAL BUFFER TYPE E-2

of maintenance money

Radial Buffer Type E-2 principles are correct.

One buffing surface is part of a cylinder—the other, part of a sphere.

The centers of both are where they should be—at the drawbar pins.

Radial Buffer Type E-2 provides positive cushioned contact between engine and tender. It precludes all possibility of slack that causes destructive shocks on drawbar and pins. It guarantees freedom of motion in any direction, yet dampens oscillation between engine and tender.

Its twin, the Franklin Automatic Compensator and Snubber, maintains constant and perfect driving box adjustment.

Both devices improve locomotive operation and greatly reduce locomotive maintenance.
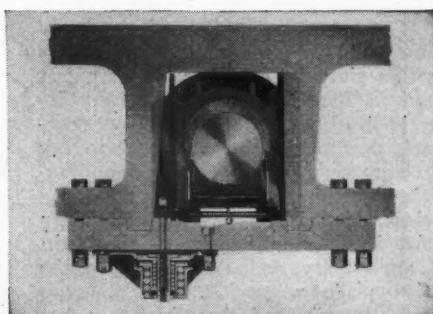
FRANKLIN AUTOMATIC COMPENSATOR
AND SNUBBER

All replacement parts furnished by Franklin Railway Supply Company are identical as to materials, design, clearances and workmanship with the parts they replace. They guarantee the same unfailing reliability of service.

FRANKLIN RAILWAY SUPPLY COMPANY, INC.

NEW YORK   CHICAGO   MONTREAL

dinner in Washington. The award, it was stated by Secretary Roper, was won because of the Association's helpful work not only to the machine tool and related industries but also to the general public, chiefly through the courageous staging of the Machine Tool Show in Cleveland, Ohio, last Fall. Seven other prizes—honorable recognition certificates — were awarded to other associations, among which were the American Institute of Steel Construction and the Automobile Manufacturers Association.

"Abraham Lincoln" on Faster Schedule

THE Alton has placed its "Abraham Lincoln" on a schedule of 4 hrs. 55 min. between Chicago and St. Louis, thereby meeting the time of the Illinois Central's "Green Diamond," placed in service on May 17. The Abraham Lincoln will leave St. Louis at 8:55 a.m. and will arrive in Chicago at 1:53 p.m. Returning the same day it will leave Chicago at 4:30 p.m. and will arrive in St. Louis at 9:25 p.m. Since April 27 this train has been hauled by the Diesel electric locomotive heretofore used on the Royal Blue of the Baltimore & Ohio.

New Seaboard Diesel Cars

THE Seaboard Air Line has recently placed in service two new streamline Diesel-electric power cars of all-welded, alloy-steel construction, built by the St. Louis Car Company and equipped with 660-hp. Electro-Motive Corporation engines. These power units, which are hauling four-car trains between Rutherfordton, N. C., Charlotte, Monroe, and Hamlet, and between Wilmington, N. C., and Hamlet, are divided into three compartments, the first housing the engine, and the second and third devoted to mail and baggage, respectively. They are 72 ft. long and 13 ft. 2¼ in. high, while the 660 hp. engines are of the eight cylinder, two cycle type.

S. M. Vauclain Honored by Newcomen Society

THE tables were neatly turned on Samuel M. Vauclain, chairman of the board of the Baldwin Locomotive Works, at a luncheon given by him to members of the American Branch of the Newcomen Society in the Junior Room of the Bellevue-Stratford, Philadelphia, on Tuesday, May 19. The guests learned that Mr. Vauclain's eightieth birthday was on the day previous, May 18. George B. Cortelyou feliciated Mr. Vauclain upon his birthday anniversary and enlarged upon the citation made when Mr. Vauclain was elected a member of the Newcomen Society.

Following Mr. Cortelyou, William Carter Dickerman, president of the American Locomotive Company, on behalf of the Newcomen Society, presented Mr. Vauclain with a beautiful silver loving cup, engraved on one side with the name of the Newcomen Society and its emblem, and on the other with these words: "Samuel M. Vauclain, great engineer, able administrator, good citizen." In responding, Mr.

Vauclain, in a happy way, outlined something of the philosophy that has carried him so successfully through his eighty years, paid a fine tribute to his mother and emphasized the value of her example and teachings in the meeting of emergencies. That he followed her teachings faithfully was indicated by the intimate recital of some of his experiences in locomotive building and industrial activities.

Labor-Management Pact on Dismissal Allowances

A FIVE-YEAR agreement covering allowances to employees affected by railroad co-ordination or consolidation projects, including two or more carriers, was announced by committees representing the railroads and the railroad labor organizations following a recent conference with the President. The agreement, reached after several months of negotiations, does away with the occasion for the enactment of the Wheeler-Crosser bill, and specifically provides that it shall not apply to changes in volume or character of employment brought about solely by other causes.

Under the agreement, each carrier contemplating a co-ordination is required to give 90 days' notice to employees affected and provision is made for adjustment of any disputes. Three provisions for financial allowances to employees are made—one providing for payment of the difference in compensation for five years for those placed in lower positions; one for payment of 60 per cent wages to employees displaced for varying periods depending on length of service, and another alternate for a lump sum separation allowance. The agreement also provides for reimbursement for expenses and losses suffered by employees required to change place of residence.

No co-ordination is to be made between carriers parties to the agreement and others not participating unless on the basis of an agreement approved by all parties to the agreement.

Demand for "Firemen" on Diesels Met by New England Roads

THE New York, New Haven & Hartford, the Boston & Maine and the Maine Central have agreed to use a "fireman-helper" on each of their present Diesel locomotives, including streamline trains, thereby settling the issue which had threatened to result in a strike of members of the Brotherhood of Locomotive Firemen & Enginemen.

In announcing its agreement the New Haven said that it has "agreed to use a fireman on present Diesel power includ-

New Equipment

LOCOMOTIVE ORDERS

Road	No. of locos.	Type of locomotive	Builder
Alton & Southern	1	2-8-2	Baldwin Loco. Works
N. Y., N. H. & H.	10 [1]	4-6-4	Baldwin Loco. Works

LOCOMOTIVE INQUIRIES

Road	No. of locos.	Type of locomotive	Builder
Southern Pacific	12	4-8-8-2	....
	6	4-8-4	....

FREIGHT-CAR ORDERS

Road	No. of cars	Type of car	Builder
Chesapeake & Ohio	1,700	50-ton hopper	Pullman-Std. Car Mfg. Co.
	1,800	50-ton hopper	American Car & Fdry. Co.
	500	50-ton gondola	Bethlehem Steel Co.
	150	Gondola	Bethlehem Steel Co.
	100	50-ton gondola	Ralston Steel Car Co.
	500	50-ton box	Pullman-Std. Car Mfg. Co.
	150	Auto-box	Pullman-Std. Car Mfg. Co.
	500	Box	General Amer. Trans. Corp.
Chicago & North Western	18	Steel underframes for 50-ton auto. box	American Car & Fdry. Co.
Missouri Pacific	1,500	50-ton box	Mt. Vernon Car Mfg. Co.
	500	50-ton hoppers	American Car & Fdry. Co.
N. Y., C. & St. L.	500	50-ton box	General American
	200	50-ton gondola	Bethlehem Steel Co.
	50	50-ton flat	Bethlehem Steel Co.
	25	70-ton gondola	Bethlehem Steel Co.
	2	100-ton flat	American Car & Fdry. Co.
Norfolk & Western	500	57½-ton hopper	Pressed Steel Car Co.
	500	57½-ton hopper	Virginia Bridge Co.
Pere Marquette	100	50-ton auto. furniture	Ralston Steel Car Co.
	400	40-ton auto.	Ralston Steel Car Co.

FREIGHT-CAR INQUIRERS

Road	No. of cars	Type of car	Builder
American Refrig. Transit Co.	1,000	40-ton refrig.	....
Southern Pacific	1,750	Box	....
	750	Auto.	....
	200	Flat	....
	100	Gondolas	....

PASSENGER-CAR ORDERS

Road	No. of cars	Type of car	Builder
Chicago, Rock Island & Pac.	4 [2]	Buffet-bagg.	American Car & Fdry. Co.

PASSENGER-CAR INQUIRIES

Road	No. of cars	Type of car	Builder
Southern Pacific	20	80-ft. bagg.-horse	....
Temiskaming & No. Ontario.	5	Coaches	....

[1] These locomotives, the purchase of which has been authorized by the trustees of the New Haven, will be streamline, roller-bearing steam locomotives of the 4-6-4 type, for fast passenger service between New Haven, Conn., and Boston, Mass. They will have a starting tractive effort of 44,100 lb., which is 6,350 lb. greater than the present locomotives used in the Shore Line service. Engine and tender together will weigh approximately 350 tons. The total weight of engine alone will be 180 tons, with 195,000 lb. on the drivers. The tenders will have water tanks of 20,000 gal. capacity and will hold 16 tons of coal. The overall length of the new locomotives, including tender, will be 101 ft. 9¾ in., and they will have a wheel base of 88 ft. 3 in. The locomotives will have one-piece cast-steel frames with integral cylinders. The 80-in. driving wheels will be cross-counterbalanced. High-tensile nickel steel is to be used in the construction of the boilers because of the unusually high steam pressure of 285 lb. The new engines are designed for the hauling of 15-car passenger trains at high speeds, and are expected to produce substantial operating economies. Delivery is expected some time in the fall.
[2] For conversion and modernization.

ing the 'Comet.' The matter of having a fireman on Diesel switching locomotives which may be placed in service at a later date was left open for future discussion on a regional or national basis."

The Boston & Maine has agreed to employ firemen as helpers in the cab of the streamline "Flying Yankee," in the cabs of its two Diesel-propelled passenger locomotives, and in the cabs of its two Diesel switching engines, it was announced by J. W. Smith, vice-president and general manager. The road agreed last February to place firemen as helpers on its streamline train and on its Diesel locomotives in passenger service, but declined to agree as regards future Diesel units. The agreement signed May 26 contains a proviso that the "management agrees to become a party to a regional or national concerted movement if and when inaugurated by the Brotherhood of Locomotive Firemen & Engine-men for the purpose of securing firemen as helpers on that type of power in switching service."

Officers of the Maine Central railroad stated that that road had signed an agreement with the B. of L. F. & E. similar to that signed by the Boston & Maine. It affects only the streamline "Flying Yankee" and a Diesel power unit operating between Bangor, Me., and Vanceboro on Maine Central lines.

Supply Trade Notes

THE NATIONAL MACHINE TOOL BUILDERS ASSOCIATION has removed its offices to 10525 Carnegie avenue, Cleveland, Ohio.

THE REPUBLIC STEEL CORPORATION has opened a sub New York district sales office in the State Bank building, Albany, N. Y., with J. M. Higinbotham, salesman in charge.

HERBERT W. SNYDER, mechanical engineer of the Lima Locomotive Works, Inc., Lima, Ohio, has been appointed also works manager.

C. E. MURPHY has been appointed sales representative of the Fansteel Metallurgical Corporation, North Chicago, Ill., with headquarters at 415 Midland Building, Cleveland, Ohio.

H. E. MENSCH has been appointed district sales agent for the Michigan territory of the Ohio Locomotive Crane Company, Bucyrus, Ohio. Mr. Mensch is located at 424 Book building, Detroit, Mich.

M. W. SMITH, who has been in charge of the design of large rotating alternating current machinery of the generator division of the Westinghouse Electric & Manufacturing Company, has been appointed manager of engineering.

THE AMERICAN STEEL FOUNDRIES has moved its New York office from 30 Church street to the New York Central building, 230 Park avenue. A new branch sales office has been opened in the Baltimore Trust building, Baltimore, Md., in charge of Charles B. Peirce, Jr.

JAMES E. NOLAN has been appointed purchasing agent of the Scullin Steel Company, St. Louis, Mo.; Harry C. Dreibuss has been appointed chief mechanical engineer and James Glover and R. C. Geekie have joined the sales department, all with headquarters at St. Louis.

STANDARD STOKER COMPANY, INC., following the death of W. C. Peyton, has elected the following officers: H. H. Wehrhane, president; R. E. Coulson, vice-president; F. P. Roesch, vice-president; E. A. Turner, vice-president; W. D. Gray, secretary; B. Peyton, treasurer.

THE YOUNG RADIATOR COMPANY, Racine, Wis., has appointed the C. H. Bull Company, 115 Tenth street, San Francisco, Calif., to handle the sale of Young heavy duty radiators, oil coolers, heat exchangers and air-conditioning equipment on the west coast.

RUSSELL D. JOHN has been appointed eastern sales manager, with headquarters at 50 Church street, New York, of The Adams & Westlake Company, Elkhart, Ind., and E. H. Leisch has been appointed district sales manager, with headquarters at Chicago.

E. J. RICHEY has been appointed sales representative of the Garlock Packing Company, New York, succeeding the late M. M. Llera. Mr. Richey was for a number of years with the Pennsylvania Railroad and the Worthington Pump & Machinery Corporation.

THE CHICAGO PNEUMATIC TOOL COMPANY has opened a new sales and service branch at 2415 Commerce street, Dallas, Texas, in charge of D. G. Reeder, district manager. The Pittsburgh, Pa., office of the company is now at 810 Chamber of Commerce building, Pittsburgh.

JOSEPH M. BROWN, railway representative of the bus and truck division of the White Motor Company, with headquarters at Chicago, and previously connected with the Elwell-Parker Electric Company, has been appointed special railway representative of the National Twist Drill & Tool Company, Detroit, Mich., with headquarters in Chicago.

C. R. COX, general superintendent of Ellwood works of the National Tube Company, has been elected vice-president in charge of engineering and operations, with headquarters at Pittsburgh, Pa., succeeding P. C. Patterson, who was associated with the Tube Company for 49 years and who had been, since 1926, vice-president in charge of engineering and operations.

A. E. WALKER, general sales manager of the Republic Steel Corporation, Cleveland, Ohio, has been elected president of the Truscon Steel Company to succeed Julius Kahn, who has been elected a vice-president of the Republic Steel Corporation in charge of production developments. Mr. Walker will continue as the sales manager of the Republic Steel Corporation.

THOMAS PROSSER & SON, New York, has discontinued the sale of Widia blanks, tools and parts thereof, the importation of Widia cutting tool material into the United States having been discontinued by the Fried. Krupp Works, Essen, Germany. The entire cemented carbide tool business of Prosser & Son, including its inventory of Widia metal, has been turned over to the Carboloy Company, Inc., Detroit.

JAMES C. TRAVILLA, of the mechanical department of the General Steel Castings Corporation, with headquarters at Granite City, Ill., has been appointed mechanical engineer in charge of the section of the mechanical department at the Commonwealth plant in that city, to succeed W. O. Ashe, who has been appointed sales engineer in the western district sales department at Granite City.

J. W. BRAFFETT, for the past seven years Detroit, Mich., representative of the Oliver Iron & Steel Corp., has joined the Detroit sales staff of the Republic Steel Corporation, Upson Nut division, with headquarters in the Fisher building; L. L. Caskey has been appointed district sales manager for the Republic Steel Corporation in the Philadelphia, Pa., territory, succeeding J. B. DeWolfe, who has been transferred to the general offices at Cleveland, Ohio, to assist George E. Totten, manager of sales of the Tin Plate division.

THE LINCOLN ELECTRIC COMPANY, Cleveland, Ohio, has made changes and promotions in its sales personnel as follows: J. S. McKeighan has been transferred to the sales staff with office at 1712 Catalpa drive, Dayton, Ohio, operating under the Cincinnati district office; J. B. McCormick has been transferred from the Philadelphia, Pa., office to the Pacific coast, with office at Monticello avenue, Fresno, Cal., under the personnel of the Los Angeles office; Paul W. James has been transferred from the factory to 16½ Crandall street, Binghamton, N. Y., operating under the Syracuse office. The Major Engineering Works has moved its offices from 210 Jackson avenue to 312 Second street, Des Moines, Iowa.

CHARLES R. ROBINSON, first vice-president and general manager of sales and a director of the Inland Steel Company, Chicago, has resigned. Mr. Robinson started his business career in 1890 as a salesman of tool steel for Park Brothers & Co. In 1900 he entered business for himself, handling various steel products on a brokerage basis. In 1904, he entered the employ of the Inland Steel Company as a salesman, becoming assistant general manager of sales in 1906. In October, 1908, he resigned from the Inland Steel Company to become district sales manager for the Lackawanna Steel Company at Chicago, and in 1910 was transferred to New York as general manager of sales. In the following year his headquarters were transferred to Buffalo, N. Y. He held the
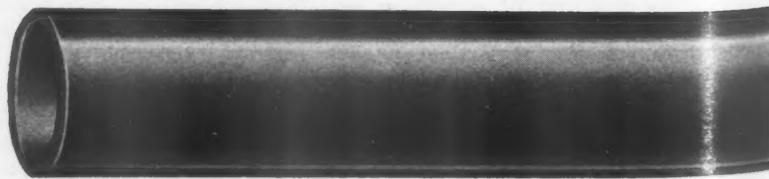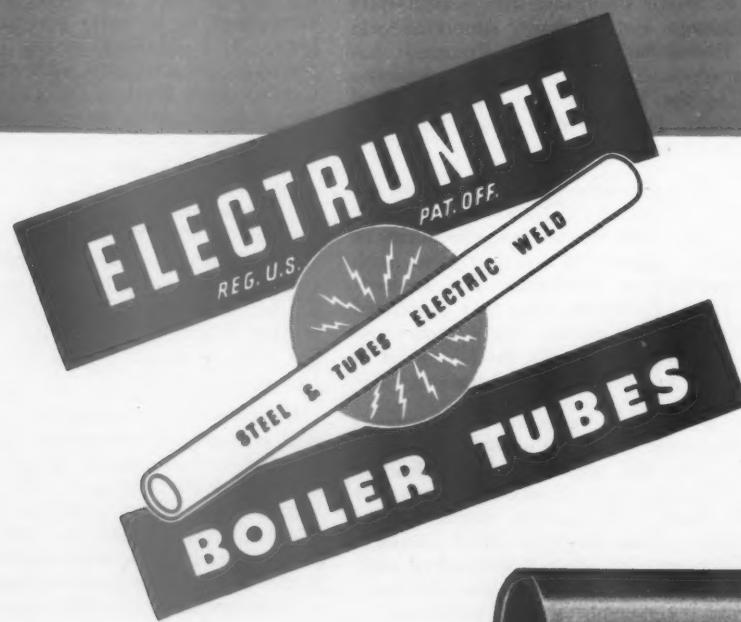
THE NORMALIZED TUBES WITH THE SCALE-FREE SURFACE

latter position until 1918, when he was elected vice-president in charge of sales. In January, 1922, he returned to the Inland Steel Company, coincident with that company's entrance into the rolling of standard section heavy T-rails, becoming vice-president in charge of railroad sales. In August, 1935, he was elected first vice-president and general manager of sales.

H. W. JOHNSON has been appointed manager of sales of the Railway Specialty department of the Lewis Bolt & Nut Company, Minneapolis, Minn. Mr. Johnson was born at Marshalltown, Iowa, on November 25, 1884. After studying mechanical engineering at Iowa State University, he entered the employ of the Minneapolis & St. Louis as machinist apprentice on

H. W. Johnson

June 1, 1902. On February 1, 1908, he became car and enginehouse foreman at Peoria, Ill.; in 1915 was appointed general foreman at Marshalltown, Iowa; in 1922 was promoted to the position of master car builder, and on August 15, 1923, became superintendent of motive power and rolling stock. Since March 1, 1935, he had been traffic representative of the Minneapolis & St. Louis.

J. G. BLUNT, mechanical engineer of the American Locomotive Company, has been appointed chief mechanical engineer, with headquarters at Schenectady, N. Y.; A. W. Bruce, designing engineer, has been appointed assistant vice-president, locomotive engineering, with headquarters at New York; E. J. Edwards, engineer of tests, has been appointed chief metallurgical engineer, with headquarters at Schenectady, and A. I. Lipetz, consulting engineer, has been appointed chief consulting engineer, in charge of research, with headquarters at Schenectady.

J. G. Blunt is a graduate of the University of Michigan, where he obtained his Bachelor of Science degree in 1894. In 1897, after a few years' experience as a machinist and draftsman with several manufacturing concerns, Mr. Blunt became a draftsman in the employ of the Brooks Locomotive Company at Dunkirk, N. Y. In 1899 he was promoted to the position of foreman and later became chief draftsman. In 1906, when the general drawing room of the American Locomotive Company was formed by moving all the subsidiary plant engineering forces to Sche-

nectady, Mr. Blunt, under the title of engineer of the drafting department, was assigned the duties of organizing these combined forces at Schenectady. Following this he was appointed superintendent of the general drawing room, and in 1916 became mechanical engineer.

A. W. Bruce is a graduate of the Worcester Polytechnic Institute (1901). From 1901 to 1903 he was employed in the drawing room of the Rhode Island Works of the American Locomotive Company and in 1904 was transferred to the calculating department of the Schenectady Works. In 1905 he accepted a position in the mechanical engineer's office of the Northern Pacific at St. Paul, Minn., and during 1906 and 1907 was with the American Car and Foundry Company at New York and Berwick, Pa. In 1908 Mr. Bruce returned to the engineering department of the American Locomotive Company at New York and was later given full charge of the specification department. In 1924 he was appointed designing engineer.

E. J. Edwards entered the employ of the American Locomotive Company as an office boy in 1906. In 1907 he was transferred to the laboratory at Schenectady, and later served successively as local engineer of tests at the Cooke and Rogers plants; in charge of heat-treating activities at various plants; laboratory foreman, and assistant engineer of tests. In April, 1917, he was appointed engineer of tests. Mr. Edwards is an active member of the American Foundrymen's Association, the American Metals Society, the American Welding Society, and the American Society for Testing Materials. Recently he was appointed chairman of a group representing the American Society for Testing Materials to co-operate with the Materials Section of the Boiler Construction Code of the American Society of Mechanical Engineers.

A. I. Lipetz, upon graduation in Russia in 1902 with the degree of engineer technologist (mechanical engineer), entered railway service as an apprentice on the Moscow-Kiev-Voronesh Railway, later serving as draftsman, engineer, inspector and assistant master mechanic. From 1906 to 1909 he was assistant professor of thermodynamics and railway mechanical engineering at the Kiev Polytechnic Institute, Kiev, Russia, passing there examinations preliminary to the degree of Adjoint of Applied Mechanics (Doctor of Engineering). For the following three years he held the positions of senior motive power inspector and chief of the locomotive department of the Taskent Railway, and from 1913 to 1917 served in the Russian Railway Administration, Ministry of Transportation, Petrograd, Russia, as chief of the locomotive department. During this period he was sent twice by the Russian Imperial Government to the U. S. A. He served the Russian State Railways in the United States, first as representative of the Railway Administration and later as assistant chief and then chief of the Russian Mission of Ways of Communication. In 1920 Mr. Lipetz joined the American Locomotive Company as European sales and technical representa-

tive, in 1925 becoming consulting engineer at Schenectady. He is the author of books and many papers on steam and Diesel locomotives and in 1930 was the reporter for America on locomotives of new types at the International Railway Congress held at Madrid, Spain. Since 1927 he has been also non-resident professor of locomotive engineering at Purdue University, Lafayette, Ind.

JOSEPH L. BLOCK, vice-president of the Inland Steel Company, Chicago, has been elected executive vice-president in charge of sales to succeed Charles R. Robinson,

Joseph L. Block

resigned, and Albert C. Roeth, vice-president, has been elected vice-president and general manager of sales. Mr. Block has been associated with the Inland Steel Company since 1922. He has been a vice-president since 1929 and a director since 1930. For a number of years he has been in charge of the sale of bars and semi-finished steel, and has also directed the company's advertising activities.

Mr. Roeth has been associated with Inland since 1911, and has been a vice-presi-

Albert C. Roeth

dent of the company since 1929. He has been in charge of the sale of structural shapes, plates and sheet piling.

FRANK B. POWERS has been appointed manager of the Railway Engineering department of the Westinghouse Electric & Manufacturing Company, to fill the vacancy caused by the recent death of Claude

Bethel. Mr. Powers was born at Chicago, and following his graduation with the degree of B. S. in E. E. from the University of Illinois, he joined the Westinghouse Electric & Manufacturing Company, attending both the engineering and the design schools as part of the company's graduate student course. After this training he helped service the 6,000-hp. Virginian Railway locomotives. On his return to Westinghouse at East Pittsburgh, Mr. Powers entered the heavy traction section of the Railway Engineering department, specializing on the design of motors for the Pennsylvania Railroad locomotives. In January, 1935, he was promoted to section engineer of all d.c. traction motors, which position he held until this new appointment.

Obituary

HOWARD P. ANDERSON, chief engineer, The Standard Stoker Company, Inc., died on May 2, at his home in Erie, Pa., at the age of 57.

EDWARD H. FISHER, connected with the sales department of the American Car and Foundry Company for 28 years, died on April 25, in New York hospital, after an illness of over two years.

WILLIAM A. LAKE, sales manager of the Railroad and Marine departments of the Pantasote Company, Inc., New York, died on May 10 after a prolonged illness in New York. Mr. Lake entered the service of the Pantasote Company in April, 1909,

William A. Lake

in its sales department, and in May, 1924, was given charge of the railroad and marine fields for the disposition of all Pantasote and Agasote products. Mr. Lake was for years an active member of various railway clubs.

WILLIAM O. JACQUETTE, formerly eastern sales manager of the Pullman Company, at New York, from which position he retired about 1925, died suddenly on the links of the Englewood (N. J.) Golf Club on May 8.

CLAUDE BETHEL, manager of the Railway Engineering department of the Westinghouse Electric & Manufacturing Company and a contributor to many important developments in the electric transportation industry, died recently after a week's illness of pneumonia.

WILLIAM BLAIR KEYS, who had been associated with the Baldwin Locomotive Works since 1911, died suddenly in Philadelphia, Pa., on April 30. Mr. Keys was born at Gordonsville, Va., on December 13, 1873. He was a graduate of Miller School

W. B. Keys

(1890). In 1892 he entered the service of the Chesapeake & Ohio as a telegraph operator; in 1896, went into the offices of

Personal Mention

General

E. L. GRIMM, assistant to the operating vice-president of the Northern Pacific, with headquarters at St. Paul, Minn., has assumed the duties of Silas D. Zwight, general mechanical superintendent, who retired on June 1.

C. E. MELKER, master mechanic of the Chicago, Burlington & Quincy at Hannibal, Mo., has been appointed superintendent of motive power, with headquarters at Havelock, Neb., to succeed H. H. Urbach. Mr. Melker was born on October 19, 1890, at Lincoln, Neb. He entered the

Charles E. Melker

service of the Burlington on May 6, 1907, as a machinist apprentice at Lincoln. Upon the completion of his apprenticeship he became a machinist and on June 15, 1916, was promoted to the position of enginehouse foreman, serving successively at

the Norfolk Southern, and from 1904 to 1906 served as assistant to the general superintendent at Norfolk, Va. He was then for a short time associated with the Atlantic Coast Line. He entered the employ of the Baldwin Locomotive Works in 1911 and later became manager of the Richmond office, in which position he served for a number of years. Upon the discontinuance of the Richmond office in 1931 Mr. Keys established headquarters at the main sales office in Philadelphia, from whence he continued to serve the Southern territory until his death.

J. O. BRUMBAUGH, representative of the Gold Car Heating & Lighting Company, Brooklyn, N. Y., died after a prolonged illness at his home in South Ozone Park, N. Y., on April 30, at the age of 70. Mr. Brumbaugh had been with this company for over 35 years.

BURTON L. DELACK, general assistant to Vice-President W. R. Burrows of the General Electric Company and until two years ago manager of the company's Schenectady works, died on May 7, following a stroke suffered at his office the previous afternoon.

Lincoln, Alliance, Neb., and Greybull, Wyo. On February 14, 1920, he was appointed master mechanic at Casper, Wyo., and on March 16, 1930, was transferred to Hannibal, Mo.

SILAS D. ZWIGHT, general mechanical superintendent of the Northern Pacific at St. Paul, Minn., has retired after 48 years of service on the road. Mr. Zwight was born on May 23, 1867, at La Crosse, Wis.,

Silas D. Zwight

and after a business-college education he entered railway service with the Chicago, Burlington & Quincy in May, 1886, with which company he served in various capacities. In June, 1888, Mr. Zwight left the Burlington to go with the Northern Pacific as a locomotive fireman on the Dakota division. Subsequently he served successively as a locomotive engineer, road foreman of engines, master mechanic, gen-

1932

1933

60,000	
58,000	
56,000	
54,000	
52,000	
50,000	
48,000	
46,000	
44,000	
42,000	
40,000	
38,000	
36,000	
34,000	
32,000	
30,000	
28,000	
26,000	
24,000	
22,000	
20,000	
18,000	
16,000	

Locomotives awaiting repairs

Locomotives Stored Serviceable

THE STEAM LOCOMOTIVE SITUATION ON CLASS 1 RAILROADS

Note how "locomotives stored serviceable" decreased from about 11,000 locomotives on January 1, 1932, to about 2,000 locomotives on March 1, 1936.

Increasing traffic would quickly wipe out this small reserve of available power.

Where will the additional serviceable locomotives come from—the repair of old power which can never operate economically at today's speeds?—or the purchase of new locomotives?

It takes Modern Locomotives to make money these days!

THE BALDWIN LOCOMOTIVE

1934   1935   1936

Total Locomotives
(on line)

Serviceable
Locomotives

Locomotives
in service
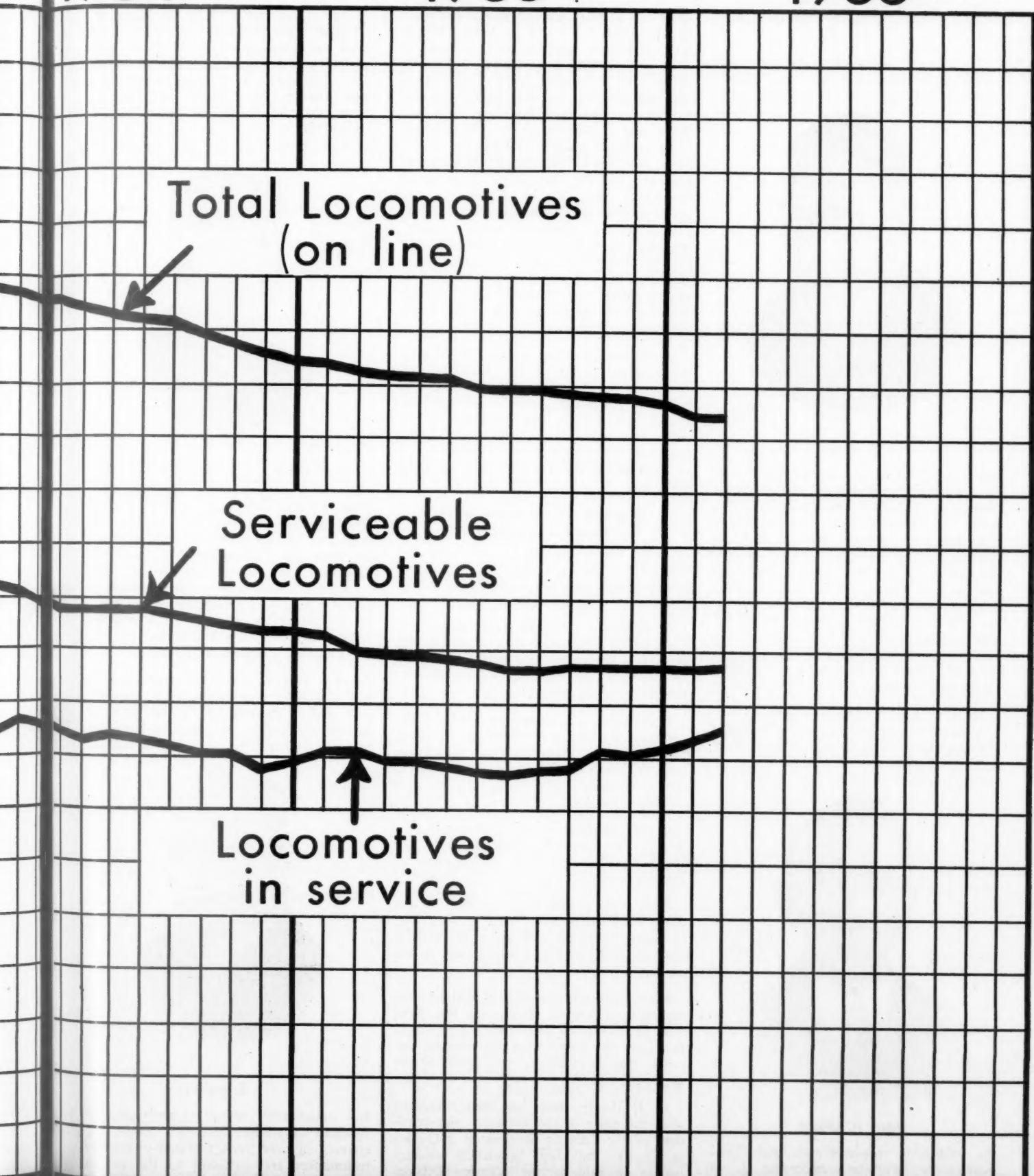
WORKS • • • PHILADELPHIA

eral master mechanic, assistant to the mechanical superintendent, mechanical superintendent and acting general mechanical superintendent. In December, 1923, he was appointed general mechanical superintendent.

J. H. REISSE, mechanical assistant to the executive vice-president of the Chicago, Burlington & Quincy, has retired. Mr.

J. H. Reisse

Reisse was connected with the Burlington for 31 years. He was born on October 14, 1880, and studied mechanical engineering with the International Correspondence Schools. After serving with the Pullman Company from 1899 to 1905, he entered the employ of the Burlington in the latter year as a draftsman at Aurora, Ill., later being transferred to Chicago. In December, 1905, he was appointed leading draftsman; in May, 1918, became chief draftsman and in May, 1925, mechanical inspector. On March 4, 1926, he was appointed mechanical assistant to the vice-president.

H. H. URBACH, superintendent of motive power of the Chicago, Burlington & Quincy, Lines West of the Missouri river, with headquarters at Havelock, Neb., has been appointed to mechanical assistant to

Henry H. Urbach

the executive vice-president, with headquarters at Chicago, succeeding J. H. Reisse, who has retired. Mr. Urbach was born on February 4, 1890, at Sutton, Neb., and entered the service of the Burlington on February 18, 1907, as a machinist apprentice at Havelock, Neb. After finishing the period of apprenticeship he served as a machinist at Havelock until July, 1914, when he was transferred to Alliance, Neb. In the following year he was transferred to Edgemont, S. D., and in April, 1915, he was appointed enginehouse foreman at Seneca, Neb., later being transferred to Alliance. In November, 1917, Mr. Urbach was promoted to the position of general foreman at Edgemont, later serving at Alliance and at Denver, Colo. He then became assistant master mechanic at Galesburg, Ill., and in September, 1923, master mechanic of the Brookfield division at Brookfield, Mo. Late in 1925 Mr. Urbach was transferred to McCook, Neb., and in July, 1926, was appointed assistant superintendent of motive power, Lines East of the Missouri river, with headquarters at Chicago. On March 20, 1927, he became superintendent of motive power, Lines West of the Missouri river, with headquarters at Havelock.

E. H. ROY, assistant general superintendent motive power of the Seaboard Air Line, with headquarters at Savannah, Ga., has been appointed general superintendent motive power, with headquarters at Norfolk, Va., succeeding C. S. Patton, who has retired from active duty after 35 years of continuous service with the Seaboard Air Line.

Master Mechanics and Road Foremen

P. S. MOCK, general foreman of the Long Island Railroad, has been appointed acting master mechanic, succeeding H. K. LeSure, transferred.

C. J. DIETRICH, general foreman of the Chicago, Burlington & Quincy at Lincoln, Neb., has been appointed master mechanic of the McCook division, with headquarters at McCook, Neb.

E. A. SCHRANK, master mechanic of the Chicago, Burlington & Quincy at McCook, Neb., has been transferred to the Galesburg-Ottumwa divisions, with headquarters at Galesburg, Ill.

F. R. BUTTS, master mechanic of the Chicago, Burlington & Quincy at St. Joseph, Ill., has been transferred to the Hannibal division, with headquarters at Hannibal, Mo., to replace C. E. Melker.

FRANK X. JONES, road foreman of engines of the eastern district of the Erie, at Jersey City, has been appointed district road foreman and fuel supervisor of the eastern district.

HOWARD BEATTIE, assistant district fuel supervisor, Eastern district of the Erie, with headquarters at Jersey City, N. J., has been appointed road foreman of engines, Buffalo division, with headquarters at Buffalo, N. Y.

C. J. HARTY, who has been connected with the office of the executive vice-president of the Chicago, Burlington & Quincy at Chicago, has been appointed assistant master mechanic of the Wymore division, with headquarters at Wymore, Neb.

W. L. CASTLEMAN has been appointed assistant to the supervisor of internal combustion engines of the Chicago Great Western, with headquarters at Minneapolis, Minn.

Obituary

S. S. RIEGEL, mechanical engineer of the Delaware, Lackawanna & Western, with headquarters at Scranton, Pa., died suddenly in Buffalo, N. Y., on May 12 of a heart attack. Mr. Riegel was born at Stouts, Pa., on November 14, 1872. He received his early education in the schools of Bethlehem, Pa., and was graduated

Samuel S. Riegel

from Lehigh University in 1897. After graduation from college Mr. Riegel was employed by the Southern Railway and the American Locomotive Company until January 1, 1909, when he entered the service of the Lackawanna as mechanical engineer. Mr. Riegel was active in affairs of the American Society of Mechanical Engineers and of the Mechanical division, Association of American Railroads.

JOHN ERNEST INGLING, supervisor of fuel and locomotive operations of the Erie, who died at Paterson, N. J., on April 14, was 62 years old. Mr. Ingling began his career with the Erie in 1897 as a fireman,

J. E. Ingling

and subsequently served as assistant road foreman of engines, assistant master mechanic, engineer, road foreman of engines, trainmaster and assistant to the general manager. He was appointed supervisor of fuel and locomotive operation in 1931, first with headquarters at New York and later at Cleveland, Ohio.